ANATOMY OF THE BRAIN

BURKHOLDER

The Anatomy of the Brain

A Manual for Students *and* Practitioners of Medicine

THE BRAIN OF THE SHEEP (OVIS ARIES) BEING SELECTED FOR DESCRIPTION AND ILLUSTRATION BECAUSE OF ITS AVAILABILITY AND ITS PRACTICAL IDENTITY WITH THE HUMAN BRAIN FOR LABORATORY USE.

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With an Introduction by

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WITH FORTY FULL PAGE PLATES (SIX OF THEM COLORED) FROM ORIGINAL DRAWINGS BY THE AUTHOR.

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PREFACE.

It *may* seem an unwarranted liberty to ask the student to add this little volume to his already overcrowded library, but after the contents have been carefully examined, I trust the intrusion will be pardoned.

I feel, as I think all teachers of anatomy do, that the teaching of the architecture of the human brain has been a failure for the average medical student, not because of a want of many very admirable works on the subject, both descriptive and practical, but on account of the great scarcity of appropriate laboratory material, or perhaps the proper appreciation of the material ready at hand. That neurology can be intelligently taught by any other than the laboratory method, no teacher has the hardihood to affirm.

In looking up the matter of anatomical material suitable for the present requirements of laboratory work in neurology, the sheep (*ovis aries*) was found to offer an inexhaustible supply, and a source easily reached. This material can be procured as fresh as need be, and at a cost quite within the reach of any institution or individual.

Its adaptability for the teaching of the anatomy of the brain to the medical student was ascertained by the dissection of a number of sheep brains, and by writing an outline of description as a guide to the student for laboratory work. This outline was mimeographed and each student was supplied with a copy and with three sheep brains, two of which were removed while the third was left in the brain case. The student then worked out each dissection as outlined and made drawings of his preparations. The experiment was an unqualified success, and removed all apprehension, so far as the neurological laboratory was concerned, in the matter of working material.

At the suggestion of Professor Donaldson of the University of Chicago, I undertook the elaboration of my first description, and the result is contained in the following pages.

This small effort is of necessity very imperfect, as little literature is available for reference; but the writer trusts that it may assist in some measure those who, like himself, are compelled to conduct a course on the brain, and who are in need of material or a laboratory guide.

The Basel association nomenclature (BNA) has been followed as closely as possible. The association name, where it is thought necessary, is followed by the common or popular names in parenthesis; this facilitates the consultation of other works on the subject.

For a like reason the following terms are employed:

CEPHALAD (anterior or toward the head).

CAUDAD (posterior or toward the tail).

VENTRAD (ventral or toward the under parts).

DORSAD (dorsal or toward the upper).

MEDIAD (median or toward the middle line) and

LATERAD (lateral or toward the side).

The terms ventral, dorsal, etc., are used as being more in conformity with the spirit of the "BNA" than the terms anterior, posterior, superior and inferior.

The drawings, with the exception of plates I and II, which are photographs, are the work of the author; they were made from dissections, and unless otherwise indicated represent the actual size of the structures under consideration.

Perhaps the only inconsistency in the work is the subdivision of the substantia alba and the substantia grisea of the medulla spinalis (spinal cord) into tracts and columns somewhat after the manner in which Toldt arranges them in the human medulla spinalis; and, furthermore, this arrangement is illustrated by means of an histological preparation, a departure from the original idea of the work that could not well be obviated. Histology, pathology and embryology may prove this arrangement to be at variance with the truth, but until such evidence is forthcoming, the description here given will be helpful.

The close correspondence between the encephalon of the sheep, and that of man, is a powerful argument in favor of a like correspondence obtaining in the medullae spinales

of the two species. Even a microscopic examination of some of the tracts of the medulla spinalis of the sheep and their course cephalad reveals the fact that their courses are not dissimilar to those taken by corresponding tracts of the human medulla spinalis.

It has been deemed advisable to confine this work to the consideration of such structures as can be identified by gross dissection, using, as occasion may require, a small hand magnifier or, preferably, an ordinary dissecting microscope. There are no structures described or illustrated, except the medulla spinalis, that cannot be worked out by a first year student of ordinary intelligence.

The dissections from which the illustrations for this book were made are now in the museum of the department of neurology of the University of Chicago.

My thanks are due Professor Donaldson for many valuable suggestions in the selection of dissections for drawing and for much assistance in properly naming various tracts, fissures and gyri. Acknowledgment is also due Dr. A. G. Wippern for assistance in arranging the nomenclature.

Thanks are especially due the publishers of this volume for the great care they have exercised in its production, particularly on account of the fidelity with which they have reproduced the original drawings. The cuts, as shown in the following pages, speak for themselves.

I wish to make special acknowledgment to Messrs. Armour & Co. for the very liberal manner in which they supplied me with material and for permitting me to collect such as best suited my purpose.

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PREFACE TO THE SECOND EDITION.

Immediately after the publication of the first edition of this laboratory introduction to the study of neurological anatomy, the author began the preparation of a serial section of the brain-stem of the sheep, stained by the Pal-Weigart method. This piece of research was due to the desire on the part of the writer to substantiate his convictions, that the relationships of the components of the brain-stem of the sheep would prove as useful in teaching the architecture of the corresponding region of the human brain, as the grosser parts have been. That this is true can be convincingly affirmed, by comparing plates XXXII to XXXVIII, inclusive, of the present edition, with illustrations of the analogous regions of the human brain, that may be found in any authoritative work on descriptive human anatomy.

The wonderfully simple figure showing the cochlear and vestibular nerves and their nuclei, as seen in plate XXXVII, is positively diagramatic in its clearness, and yet this complex mechanism is thus perspicuously shown in the space of a half dozen sections.

The original idea, that the book should contain the description of no structure that could not be seen by a hand glass or dissecting microscope, has been strictly followed in the second edition. Most of the minute structures that are mentioned, however, such as those that occur in the stained sections of the brain-stem, can be seen with the unaided eye. Moreover, many of these structures can be identified in unstained sections without an immoderate exertion of the imagination. For demonstrations of this character, sections should be cut as thin as possible under water, using a sharp thin-blade razor, and placing the specimen on parafined cork or dissecting wax.*

One gratifying result that may, in a measure, be attributed to this laboratory guide, is the incentive it has given to the study of unstained sections of brain tissue. Specific

directions, that will very materially facilitate this method of study, are given in the text.

Furthermore, we cannot insist too forcibly upon the tearing process, in facilitating the dissection of the brain. The study of the larger bundles of fibres is greatly aided by this method of work. When the sheep's brain is used as a source of laboratory supply, there is no reasonable necessity for being inordinately sparing of brains; and the student, if permitted to use the necessary material, will very soon acquire a true and lasting perspective of this intricate organ.

Henle made frequent use of this tearing process of dissecting the human brain as shown in Vol. 3 of his human anatomy published in 1868. We are not paying sufficient attention to these so-called primitive methods in this day and age of complicated laboratory and often unsatisfactory technic, and we and our students are the losers thereby.

Thanks are due Professor Herrick of the University of Chicago for suggesting the introduction of figs. D. and E., which show more clearly than the original plates the foramen interventriculare and the attachments of the pia and arachnoid to the dorsal surface of the medulla oblongata. Thanks are due Dr. Wippern for his care in correcting the proofs. And again, my thanks are due to the publishers for the accuracy with which they have reproduced my original drawings.

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*Preparation of Dissecting Wax. Formula:

Bees wax (white or yellow)	4 oz.
Parafin (50°)	4 oz.
Colophonium	1 oz.
Canada Balsam	½ oz.
	mix.

Place the ingredients in the desired container and melt. Stir while cooling until the mixture begins to congeal on the sides of the vessel; then allow to stand in a cool place. Do not allow the bottom of the dish to get cold too quickly. Let the mass get quite cold before using.

If a black mass is desired, add a tablespoonful of lamp black.

Commercial rosin should not be substituted for colophonium.

This mass does not shrink, crack, not get brittle; neither is it effected by cold. It is very tenacious to the dish and dissecting pins.

INTRODUCTION.

During the last few years increasing emphasis has been laid on the study of the brain as a part of the anatomical training of students preparing for medicine.

In many places where this preparatory work has been introduced, human brains are difficult to obtain, and for this reason mainly, the study of this organ is limited to a few demonstrations.

It may be assumed that for some years, at least, it will not be possible to relieve the difficulty arising from the scarcity of human material. Under these circumstances, it seemed desirable to prepare a description of a brain of moderate size, which might be used in place of the human brain, thus allowing the student to have the entire specimen under examination, and study it at his leisure. This, of course, is by no means a new idea, since the work in the Zoölogical Laboratory at Cornell University under Professor Burt G. Wilder has for years been conducted on this principle, and furthermore he has there used the sheep's brain for the purposes of dissection.

All things considered, there is no more accessible material of the proper size than the brain of the sheep, and for the purpose of utilizing this, the present book has been prepared.

The directions for the study of the specimen assume that it is the purpose of the student to obtain a good three-dimensional impression of the brain with which his topographical terms may be associated. This is much facilitated where the text and figures apply directly to the specimen in hand, and it therefore seemed worth while to bring together the accompanying drawings, explained by a brief text, in a form where they could be used in connection with the laboratory work.

The chief difference between the brain of the sheep and that of man is, apart from size, first in the cranial flexure, which is much less developed in the sheep; second, in the relative size of the cerebellar hemisphere; and third, in the proportional development and sculpturing of the cerebral hemispheres. All of these differences are readily

appreciated by the inspection of demonstration specimens or figures representing them.

On the other hand, the student's greater difficulties arise in the attempt to understand the deeper lying parts represented by the inter-brain and mid-brain, together with the ventricular cavities. To comprehend these, careful dissection is required, and this, fortunately, can be just as well carried out on the brain of the sheep as on that of man.

It will be seen from turning the pages, that most of the appearances described in the text can be observed with the unaided eye, and the statements have been so formulated as to guide the student in making his own observations rather than to present him with a comprehensive account of the several structures.

This book meets a need that has been felt for some years, and if at the same time arrangements can be made with the firms dealing in sheep to remove the brains and supply them to laboratories at reasonable prices, one mechanical difficulty standing in the way of the study of the brain will have been removed.

It is as an aid to this end that Dr. Burkholder has prepared the following description of the figures of the sheep's brain, all of which were drawn by himself from his own careful dissections.

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CHAPTER I.

THE BRAIN—ITS REMOVAL AND PREPARATION.

THE ENCEPHALON OF THE SHEEP (*ovis aries*).

The encephalon (brain) consists of four large subdivisions:

CEREBRUM,
CEREBELLUM,
PONS, and
MEDULLA OBLONGATA;

all inclosed within the cranial cavity, the walls of which in the adult are osseous, and the sutures of the calvarium obliterated.

To remove the encephalon without injury to its coverings or the nervi cerebrales requires care, as laceration of these structures may lead to erroneous conceptions, or at least endanger a proper conception of the normal relations.

The following instruments are necessary for dissecting: a large and a small bone forceps, a brain knife, small scissors, scalpel, and a pair of dissecting forceps with sharp points; all of which must be of good quality and in prime condition. Nothing is more disastrous to good dissecting than poor instruments in poor condition.

Begin with the bone forceps at the cephalic extremity of the cranium just behind the frontal edge of the orbital fossae (Plates I and II A). The first incisions will open the large frontal sinuses, the inner walls of which form the outer walls of the brain-case.

Working caudad, clip away small portions of bone until an opening is made and the outer covering of the encephalon is reached. Proceed now with the greatest care; with the handle of the scalpel, pry the dense white membrane "the dura mater" away from the skull before further clipping away the bone, a small portion at a time. Unless this precaution is taken this membrane will surely be lacerated.

It will be noticed that the dura mater is more firmly attached to the inner surface of the skull along the middle line than at the sides, while the locations where the attachment is greatest will be seen to be at the sutures or seams between the ossa cranii.

Remove the calvarium as far caudad as the sutura lambdoidea (Plate I B), which separates the os parietalis from the os occipitale; then proceed from the foramen occipitale magnum—out of which passes the medulla spinalis—clipping away the condyli occipitales, and finally the remainthe portion of the os occipitale. Note how tightly the dura clings to the cephalic portion of the bone, particularly at the sutura lambdoidea. In clearing away the lateral walls of the brain-case, caution must be exercised not to lacerate the nervi cerebrales.

For the student of human anatomy preparing for the study of medicine, a further use of the skull can be made for the purpose of getting an idea of the arrangement of the internasal bones, and the distribution of the Nn. olfactorii. Remove the nasal bones by means of the bone forceps, and a veritable labyrinth of convoluted bony structures will be exposed. These are the *turbinal bones* (*conchae ethmoideales*) or the *ethmoturbinals.*

The Nn. olfactorii can be traced for some distance, by using a reasonable amount of care, showing their distribution to the *Schneiderian membrane* covering the superior turbinal bones. This dissection requires very little skill, and consumes a modicum of time.

CHAPTER II.

THE COVERINGS OF THE BRAIN.

Having removed the brain-case, a drawing should be made of the exposed dura, of the Sinus Sagittalis (longitudinal sinus), the Sinus Transversus (lateral sinus), and the Confluens Sinuum (Torcular Herophilii), exposed as directed in the description of the dura mater, and shown in Plate III.

The student may now proceed in one of two ways; either the dura can be wholly reflected and the encephalon removed and placed in a ten per cent solution of formalin, or a long incision may be made over each cerebral hemisphere through the dura and the whole skull with the attached brain placed in the solution. In either case it must remain in a solution of this strength for four or five days, and then be kept in a five per cent solution as long as required for dissection and study.

In removing the encephalon, proceed from the caudal extremity, clipping away the nervi cerebrales close to the foramina through which they pass (Plates VII and XXXIX), preserving at least 1 cm. of the nervi optici, and taking care to remove the whole of the bulbi olfactorii from their fossae; be particularly careful with the N. facialis and the N. acusticus.

Each time the brain is to be studied it should be placed in water for an hour to remove the formalin. This procedure obviates the irritation of the conjunctiva and respiratory mucous membranes, which the vapor of formalin will cause if allowed to circulate through the laboratory.

MENINGES.

These membranes surround the encephalon for its protection and partial nourishment. There are three of them, and from without inward are called:

Dura,

Arachnoid, and

Pia.

The dura is the first exposed on removing the calvarium, the pia is closely attached to the encephalon, and the arachnoid lies between the two.

CHAPTER III.

DURA MATER ENCEPHALI.

(DURA, HARD; MATER, A MOTHER.)

The dura (Plate III) is the strongest of the three membranes, and not only protects the encephalon, but by sending projections from its inner surface, between the hemisphaeria cerebri and between the cerebrum and the cerebellum, acts as a support. This membrane consists of white fibrous tissue arranged in bundles or strands that run in many different directions.

Over the hemisphaeria cerebri, vermis cerebelli and hemisphaeria cerebelli, it is quite thin and cannot be separated into distinct layers. The thickest and densest part of the membrane, as previously mentioned, lies directly beneath the sutura sagittalis and the sutura lambdoidea. At the cephalic extremity there is a triangular thickening consisting of two of three layers; the apex of this triangle points caudad in the middle line, the base cephalad and ventrad into the cephalic extremities of the fossae olfactoriae. The gyri, and sulci cerebri can be seen somewhat indistinctly through the thinner parts of the membrane.

The dura consists, roughly speaking, of two layers, an outer and an inner, the former, constituting the endosteum of the ossa cranii, is very firmly attached to the inner surfaces of the cranium, and particularly so at the sutures, into which fibrous bands of dura pass. Between this layer and the bone is a large number of arteries of various sizes, called the arteriae meningeae, which supply the dura and the inner table of the ossa cranii. This outer layer of the dura also gives off tubular prolongations which surround the nervi cerebrales as they pass through the various foramina; that accompanying the nervus opticus divides as the nerve emerges from the foramen opticum, into its two primary layers, the inner continuing as a sheath for the nerve forming its epineurium, while the outer unites with the periosteum of the fossa orbitalis.

The inner layer of the dura as it lies over the fissura longitudinalis cerebri, and the fissura transversa cerebri, leaves the outer layer and dips into these fissures. That which rests in the fissura longitudinalis cerebri is called the falx cerebri, very slightly developed in the sheep; that in the fissura transversa cerebri is the tentorium cerebelli. Where the falx cerebri and the tentorium cerebelli leave the outer layer, and in various locations on the base of the cranium, the two layers of the dura separate and leave large spaces of various shapes called sinuses, which convey venous blood from the encephalon. These sinuses, like veins, are lined with endothelial cells.

The Falx Cerebri has the shape of a sickle, hence its name, and begins about 2 cm. caudad of the cephalic extremity of the encephalon where it is exceedingly narrow and receives the vena frontalis. It widens as it proceeds caudad, and is firmly attached to the sagittal centre of the tentorium cerebelli. It is quite narrow even at its widest portion and, really is suspended between the hemisphaeria cerebri only at their caudal extremities. The long triangular canal inclosed by the falx cerebri and the outer layer of the dura is called the *sinus sagittalis,* analogous in location to the sinus sagittalis superior (superior longitudinal sinus) in man. The flow of blood in this sinus is directed toward the caudal extremity of the encephalon.

As the falx proceeds caudad, numerous veins enter its sharp concave border to empty blood into the sinus sagittalis. A large vein, the V. cerebri magna (vein of Galen), enters the falx about 6 mm. cephalad to the tentorium. This vein conveys blood from the plexus chorioideus of the lateral and third ventricles and the lobi occipitales (caudal extremities of the hemispheres).

The Tentorium Cerebelli, the other reflection of the inner layer of the dura, forms a partial roof over the fossa cranii posterior. This layer or tent is membraneous in the sheep and in man; but is osseous in some species, as the cat, dog, lion. As you follow the falx cerebri caudad and ventrad it suggests the parting of the falx into halves which gradually diverge, leaving a large, somewhat tri-

angular opening, through which passes the mesencephalon, composed of the structures connecting the cerebrum with the cerebellum, pons, and medulla oblongata.

The inner margins of the tentorium are thus free, while its outer borders are attached to the outer layer of the dura lining the cranium. The free margin is thin, but where the structure is attached to the outer dura it is very thick, and at the point where the falx meets the tentorium will be found a large triangular thickening in the outer portion of which rests the confluens sinuum.

Traced cephalad along the basis cranii, the tentorium is attached laterally to the external lip of the sulcus caroticus and blends gradually with the dura lining the fossa cranii media (Plate XXXIX). As the tentorium proceeds cephalad it becomes greatly thickened, and almost tendonous in character.

The sinuses, as previously stated, are spaces between the two layers of the dura and convey venous blood.

The Sinus Sagittalis (Plate III). Make an incision in the sagittal line of the dura mater about 4 cm. from the cephalic extremity of the encephalon, and the sinus will be exposed; pass a bristle cephalad as far as possible without using force, and then dissect it out, and the sinus will be seen to end in the V. frontalis within about 2 cm. of the cephalic extremities of the lobi frontales, which are drained by this vein. Traced caudad, the sinus enters the confluens sinuum.

The Confluens Sinuum is situated where the falx and the tentorium meet, directly beneath the protuberantia occipitalis externa. Leading from the confluens sinuum at each side is a *sinus transversus* which follows for some distance the attachment of the tentorium.

These sinuses finally enter the substance of the os occipitale, through which they run for a short distance and then re-enter the cranial cavity close to the foramina condyli anteriora where each enters a large sinus, the *sinus basilaris magna* resting on the os basilare (Plate XL). This sinus is wide ventrad but gradually becomes smaller as it passes dorsad, the two extremities not quite meeting in the

dorsal midline. Pass a bristle along each sinus transversus and dissect each out with the bone forceps. The sinus basilaris magna is drained by the two venae vertebrales that leave the cranial cavity through the foramen occipitale magnum, one on either side of the medulla spinalis.

The large V. ophthalmica enters the fossa cranii media through the fissura sphenoidalis, bringing blood from the orbit (Plate XL). This vein enters the *sinus cavernosus*. Each sinus cavernosus rests in the sulcus caroticus on either side of the corpus sphenoidale.

Running almost completely around the hypophysis is the *sinus circularis;* on each side this sinus communicates freely with the sinus cavernosus.

The sinus circularis and the sinus cavernosi contain a fine reticulum of connective tissue, arranged somewhat after the manner of the cancellous tissue in bone.

In each sinus cavernosus will be seen a very dense plexus of small arteries, called the *rete mirabile* (Galen) which will be described in connection with the arterial circulation on the ventral surface of the encephalon.

As each sinus cavernosus passes caudad it lies mediad to the N. trigeminus, the fibrous sheath (epineurium) of which is firmly attached to the external wall of the sinus.

Passing through the sinus cavernosus are the N. oculomotorius, N. trochlearis, and the N. abducens on their way to the fissura sphenoidalis; the sinus cavernosus empties into the *sinus petrosus inferior* which runs along the ventral border of the pars petrosa of the os temporale and ends at the foramen jugulare by entering the V. jugularis interna. A bristle should be passed along the sinus petrosus inferior and dissected out by means of the bone forceps.

In this connection a very nice dissection can be made of the ganglion semilunare (Gasseri) showing the origins of the N. ophthalmicus, N. maxillaris, and the N. mandibularis. The dissection should begin at the fossa temporalis and be carried mediad, proceeding carefully when the region of the sinus cavernosus is reached.

At this stage the student must cease operations on the basis cranii, which are to be resumed when working out the

exit of the nervi cerebrales from the cranial cavity. Perhaps the better way to make this latter preparation would be to decalcify the basis cranii by immersing it in a ten per cent solution of commercial nitric acid in water, after which the nervi cerebrales can be easily removed with the dural processes surrounding them.

CHAPTER IV.

ARACHNOIDEA ENCEPHALI.

(ARACHNE, SPIDER'S WEB; EIDOS, LIKE.)

The arachnoid is a membrane of very uncertain quantity and variable in its character and distribution. As a rule it covers the entire encephalon and lies immediately beneath the dura, and the space between it and the dura is called the cavum subdurale.

This membrane is most easily identified in the region immediately caudad to the cerebellum, where the dura and the arachnoid are reflected from the vermis to the dorsal surface of the medulla oblongata; as a rule the membrane is continued as a tubular prolongation over the medulla oblongata thence to the medulla spinalis.

The space beneath the arachnoid is the *cavum subarachnoideale,* and at certain places this space is quite deep, as in the angle made by the cerebellum with the medulla.

At the fossa interpeduncularis, and other limited places, these deep spaces are called the cisternae subarachnoideales, and are filled with a very delicate reticulum of tissue which, like all the spaces between the arachnoid and the pia, contains the cerebro-spinal fluid.

The reticulum forms the trabeculae subarachnoidealae. Place a small quantity on a slide in glycerine and water; tease under a dissection microscope, and study. Clip a small piece of arachnoid from that covering the hemisphaerium cerebri; mount in glycerine; it will present, mingled with a few elastic fibres, a very fine reticulum of white fibres which, under a dissecting microscope, looks like ground glass. Under a higher power a very beautiful plexus of capillaries and arterioles can be seen, many of them containing blood. A large number of arteries can be seen passing through the trabeculae subarachnoidealae, but the tissue itself is nonvascular. The trabeculae are most abundant on the ventral surface of the encephalon and contain much fluid which acts as a water-bed for the

organ it supports; while over the convexities of the hemisphaeria cerebri the fluid is very scarce, though more abundant beneath the portions of arachnoid that lie over the sulci cerebri.

CHAPTER V.

PIA MATER ENCEPHALI.

(PIA, TENDER; MATER, A MOTHER.)

The pia mater is an exceedingly thin membrane in contact with the encephalon; and containing vessels in large quantity, it provides nutrition for the entire substance of the brain cortex.

This delicate membrane dips to the bottom of the various sulci and during the development of the organ is pushed through the fissura transversa cerebri (great transverse fissure) into the ventricular cavities of the encephalon, where it will be further studied, when describing those spaces.

At the cephalic extremity of the encephalon there is in the cells of the pia a deposit of *pigment granules* which in some instances assumes the form of a large triangular patch, lying beneath the similarly-shaped thickening of the dura. This deposit of pigment is black and may be scattered in various other locations, notably on the ventral surfaces of the lobi frontales. In some encephala this pigment will be found as far caudad as the medulla spinalis. Animals killed at different seasons of the year do not show any regular variation in the quantity or the extent of distribution of this pigment; but from the limited number of specimens examined, it appears to be much less in lambs under one year than in adult sheep.

Toward the caudal extremity of the medulla oblongata, the pia is greatly increased in density and thickness as it becomes the pia of the medulla spinalis. In this location two distinct layers can be distinguished; an external, whose fibres run longitudinally, and an inner with transverse fibres, the latter appearing to be the more numerous. Examine a small portion under the dissecting microscope.

In the region of the medulla spinalis, and the caudal portion of the medulla oblongata this thickened pia is furthermore greatly increased laterally, forming the *liga-*

mentum denticulatum; lying between the dorsal and ventral roots of the Nn. cerebrales, and passing cephalad, ventral to the roots of the N. accessorius.

The lateral border of this ligamentum denticulatum occasionally takes the form of a white fibrous cord, which runs parallel to the spinal portion of the N. accessorious. This cord may be mistaken for a part of the nerve, which in this neighborhood, is occasionally divided into two well-defined fasciculi, quite similar in color and consistency to the ligamentous cord.

These ligaments on each side appear to blend with the dura, as it forms the tubes for the exit of the Nn. glosso-pharyngei, Nn. vagi, and Nn. accessorii.

At the point where the pia is reflected from the caudal surface of the cerebellum to the dorsal surface of the medulla oblongata, there is occasionally, a median foramen, called the apertura mediana ventriculi quarti (foramen of Magendie).

If we trace the pia a short distance caudad on the medulla spinalis, it will be seen to lose its excessive thickness, and becomes the delicate fibro-vascular membrane usually described.

CHAPTER VI.

BLOOD VESSELS AT THE BASE OF THE BRAIN.

The blood supply (Plate IV) to the encephalon is almost entirely derived through the *arteria carotis interna* on either side. The internal carotid artery, after it is given off from the common carotid, enters the cranial cavity through the foramen ovale, passing ventrad to the proximal extremity of the N. mandibularis which leaves the cranial cavity through the same opening. As the artery enters the cranial cavity it lies opposite the caudal extremity of the fossa hypophyseos, where it immediately divides into a plexus of small arterioles, the rete mirabile, which in their turn similarly divide, and so on until the whole of the sinus cavernosus is completely filled with small arteries in a manner similar to the arrangement of the vas afferens in the kidney forming the glomerulus inside the capusula renis. This plexus of vessels also invades the fossa hypophyseos occupying all the space not taken by the hypophysis and sinus circularis.

The vessels from the two sides come very close together caudad to the hypophysis, but the arteries of one side do not anastomose with those of the other. The small arteries are finally gathered together, opposite the centre of the hypophysis and form one large artery on each side, the *arteria propria cerebri.*

These pierce the dura which forms the roof of the sinus cavernosus on either side of the foramen diaphragmatis sellae and at once divide into two rami nearly opposite the infundibulum, the *ramus anterior* passing cephalad, and the *ramus posterior,* caudad. The former runs cephalad in the sulcus between the tractus opticus and the lobus hippocampi; it then turns sharply mediad, and in some cases runs almost parallel with the tractus opticus.

When this anterior ramus reaches the nervus opticus it divides into two branches, the A. CEREBRI ANTERIOR, continuing on as the apparent extension of the ramus anterior

to the fissura longitudinalis cerebri, and the A. CEREBRI MEDIA passing directly laterad in the fissura cerebri lateralis (fissure of Sylvius). The latter artery is widely and irregularly distributed to the lateral aspect of the hemisphaerium cerebri, passing dorsally in some instances as far as the fissura longitudinalis cerebri, supplying also a considerable portion of the external surface of the lobus frontalis and the lobus parietalis.

The A. cerebri anterior passes cephalad usually on the ventral surface of the lobus frontalis, and is distributed to the facies ventralis and the facies medialis of this portion of the encephalon. As the Aa. cerebri anteriores pass cephalad they anastomose at one or more points, permitting a free communication between the vascular systems of the two sides. At the bifurcation of the A. propria cerebri, a large branch is usually seen, the *A. cerebri posterior*, which may arise either from the ramus anterior or the ramus posterior. It passes laterad and caudad across the pedunculus cerebri and is soon hidden by the lobus hippocampi. It is distributed to the facies medialis and the facies ventralis of the lobus occipitalis.

The rami posteriores pass caudad and converge to meet beneath the fossa interpenduncularis, where the nervi oculomotorii (third pair of cranial nerves) emerge from the pedunculi cerebri (crura cerebri), forming the *arteria basilaris;* this artery runs directly caudad in the middle line on the ventral surface of the pons, and the medulla oblongata.

As the ramus posterior reaches the N. oculomotorius it gives off a branch, the *A. basilaris gangliaformis posterior* that passes laterad, cephalad to the root of the nerve, winds around the pedunculus cerebri, and is distributed to the pulvinar, corpora geniculata, and the corpora quadrigemina.

Just before the rami unite, a large branch, the *A. cerebelli anterior* passes laterad and is distributed to the facies dorsalis and the facies lateralis of the cerebellum; it runs caudad in the sulcus between the vermis and the hemisphaerium cerebelli, to anastomose with the artery next to be described, the *A. cerebelli posterior.*

This artery arises from the A. basilaris as it passes over

the groove between the pons and the medulla oblongata. It lies dorsad to the N. abducens, supplies the dorsal and lateral surfaces of the medulla oblongata as well as the neighboring parts of the cerebellum; it then passes dorsad and cephalad to meet the A. cerebelli anterior.

On proceeding caudad the A. basilaris gives off small branches from either side which are distributed to the ventral surface and sides of the medulla oblongata. In the region where the medulla oblongata merges into the medulla spinalis, the A. basilaris breaks up into a spray of little branches which are distributed to the adjacent parts; at its caudal extremity the artery can be seen anastomosing with the A. spinalis ventralis, which passes caudad throughout the entire length of the medulla spinalis.

There is a very peculiar and useful arrangement of the larger arteries on the ventral surface of the central portion of the encephalon called the *circulus arteriosus* (circle of Willis). As the Aa. cerebri anteriores approach the midline, just cephalad to the chiasma opticum, they are connected directly or indirectly by one or more small arteries called the Aa. communicantes anteriores, thus completing the cephalic portion of the circle, while the caudal part is formed by the union of the rami posteriores.

A drawing should be made of the ventral surface of the encephalon showing the circle, the proximal portion of its branches, and the other structures of interest. The obvious functions of this circle formed by the anastomosis are to supply a constant quantity of blood to the encephalon in an even stream, with a like degree of pressure in every direction, and to insure a free supply to the whole encephalon, should one or the other of the sources of blood to the circle be obliterated.

The student should bear in mind that the formation of the circulus arteriosus of the sheep differs from that of the human brain, where there is an additional supply of blood supplied by the large Aa. vertebrales.

CHAPTER VII.

THE EXTERNAL SURFACE OF THE BRAIN.

THE HEMISPHAERIA CEREBRI.

The hemisphaeria cerebri are two symmetrically arranged portions of the encephalon, separated by the FISSURA LONGITUDINALIS CEREBRI, constituting its largest subdivisions.

The outermost or ectal portion of each hemisphaerium, that which is seen after the encephalon is cleared of its meninges, is the PALLIUM. It is characterized by a series of long, narrow folds, much convoluted, which have a somewhat definite and regular arrangement.

The sagittal diameter of the cerebrum is about 7 cm., the greatest transverse diameter about 6 cm., while the dorsoventral will average about 4 cm.; these measurements vary somewhat in different specimens.

The external layers of the pallium consists of the cell bodies of myriads of neurones (nerve cells) which constitute a part of the substantia grisea or cortex of each hemisphaerium. Internal to this substantia grisea is the substantia alba, composed principally of medullated fibres of the neurones (axones with their sheaths). Make a small wedge-shaped incision into one of the gyri cerebri, and the differentiation of the cerebral matter into substantia grisea and substantia alba can be easily verified.

The following short method of staining the substantia grisea to show its constituent neurones can be easily carried out. A small quantity of substantia grisea is placed on a coverglass, and a second coverglass placed directly on it and squeezed down so that the nerve substance is smeared evenly over both glasses. The covers are then separated and floated for two hours, film downward, on a saturated aqueous solution of methylene blue. They are then washed in distilled water and dried; finally, after exposure to a gentle heat to thoroughly dry them, they are mounted in balsam.*

*H. L. Osborn, Journal of Applied Microscopy, Vol. 1, p. 7.

The irregular depressions on the surface divide each hemisphaerium into gross subdivisions called lobi cerebri, and these again into gyri cerebri (cerebral convolutions). The larger depressions are called fissures; those separating the gyri, which are smaller are called sulci.

The layer of substantia grisea constituting the cortex is not an homogeneous mass of matter with the neuron bodies arranged in a heterogeneous manner. These neuron or cell bodies are arranged in definite stratae, which in some specimens prepared by the Kaiserling method, can be faintly seen by the unaided eye.

CHAPTER VIII.

DORSAL SURFACE OF THE CEREBRUM.

On the *facies dorsalis cerebri* (Plates V and IX) of each hemisphaerium is a transverse fissure called the *fissura cruciata*. It lies about 2.5 cm. caudad to the cephalic extremity of the encephalon, is inclined slightly cephalad as it passes laterad and separates the lobus frontalis from the lobus parietalis.

The fissura cruciata in some specimens does not reach the lateral border of the dorsal surface, but rests between the caudal extremity of the gyrus frontalis medialis and the cephalic extremity of the gyrus parietalis externus (*gyrus lateralis*).

The facies dorsalis of the lobus frontalis is divided into too well-defined gyri: a mesial, called the *gyrus frontalis superior*, and a lateral, the *gyrus frontalis medialis*.

These gyri are separated from each other by the *sulcus coronalis* which is really a prolongation of the fissura cruciata; this fissure passes cephalad in the sagittal plane and terminates in a bifurcation near the polus anterior. The gyrus frontalis superior is in most cases somewhat depressed, particularly at its caudal extremity, where a well marked notch appears which is the cephalic termination of the sulcus splenialis (Plate IX). In many specimens the A. cerebri media leaves the fissura cerebri lateralis and continues its course in the fissura cruciata to reach the neighborhood of the fissura longitudinalis cerebri.

There is another very important and well marked fissure situated on the facies dorsalis called the *fissura suprasylvia*. This fissure begins on the facies lateralis cerebri about 1 cm. cephalad to the middle of the fissura cerebri lateralis; it then passes caudad and dorsad winding around the summit of the fissura cerebri lateralis lying about 2.5 cm. laterad to the fissura longitudinalis. The further course of the fissure runs in a caudo-laterad direction, reaching in some instances the tentorial surface of the lobus occipitalis. The

caudal two-thirds of the fissura suprasylvia separates the parietal from the temporal lobe.

Occasionally the lateral extremity of the fissura cruciata appears to pass directly into the fissura suprasylvia, but if the student takes the trouble to open the fissure he will see that this condition is only apparently so. At this point there is a more or less well developed gyrus hidden from view.

The facies dorsalis of the lobus parietalis is divided, in the adult specimen, by three well developed sulci, that may be named, *sulcus lateralis, sulcus medialis* and *sulcus intermedia,* which run in a caudo-laterad direction, parallel with the caudal portion of the fissura suprasylvia.

These sulci divide the lobi into four gyri, an external, an internal and two mesial. These gyri become larger and longer from the fissura longitudinalis, laterad. They run to the polus posticus, and at irregular intervals are divided by transverse depressions that form shallow sulci. These four parietal gyri are very constant, and in no instance was there observed any evidence of the separation of a lobus occipitalis. The gyrus lateralis, in many instances, extends cephalad to the fissura cruciata, and, winding around the extremity of this fissure, forms a connection with the lobus frontalis. This arrangement is nicely shown in the right hemisphere as seen in Plate V.

In most cases the fissura cruciata lies beneath the os parietale, but occasionally it lies directly beneath the sutura coronalis, and thus the parietal lobe is almost wholly covered by the parietal bone.

Slight variations in the manner of the arrangement of some of the gyri and sulci are seen in most specimens. In fact, the arrangement is not always the same, even in the two hemispheres of the same brain. The gyri and sulci of the human enaphalon are not exempt from such variations. The fissura cerebri lateralis (Sylvius), however, never varies; it is invariably in the same relative position.

Professors Simpson and King of Cornell University*

*Quarterly Journal of Experimental Physiology, Vol. IV, No. 1, 1911.

have done a splendid piece of research on the motor areas of the cerebrum of the sheep, which must be mentioned in this connection and which we have illustrated by three figures: A. B. C. taken from plates V, VIII and IX. These physiologists place these centres in the gyrus fron-

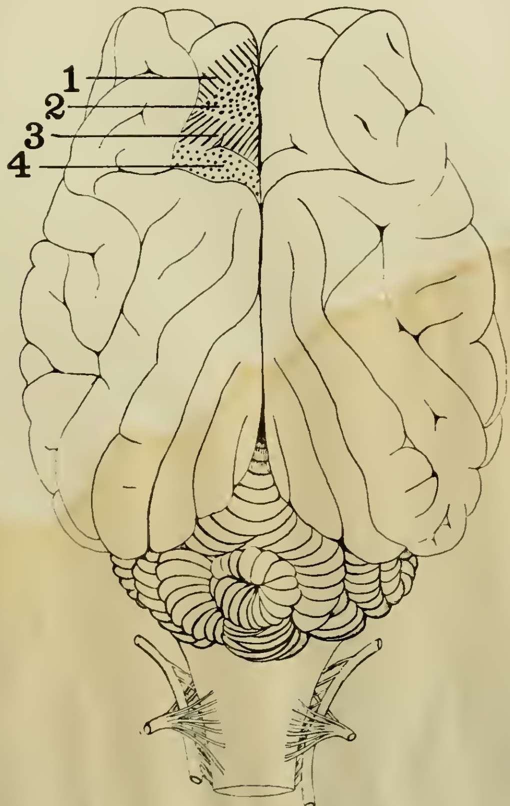

FIG. A.

This figure illustrates the dorsal surface of the brain. The lines and dots on the super frontal convolution of the left cerebral hemisphere show the motor areas.

talis superior of the left hemispherium. They occupy the exposed surface of the gyrus to within a short distance of its ventral border. This excitable area winds over the

free border of the gyrus onto its mesial surface for a distance of 1 mm.

They have not only shown where the motor area is lo-

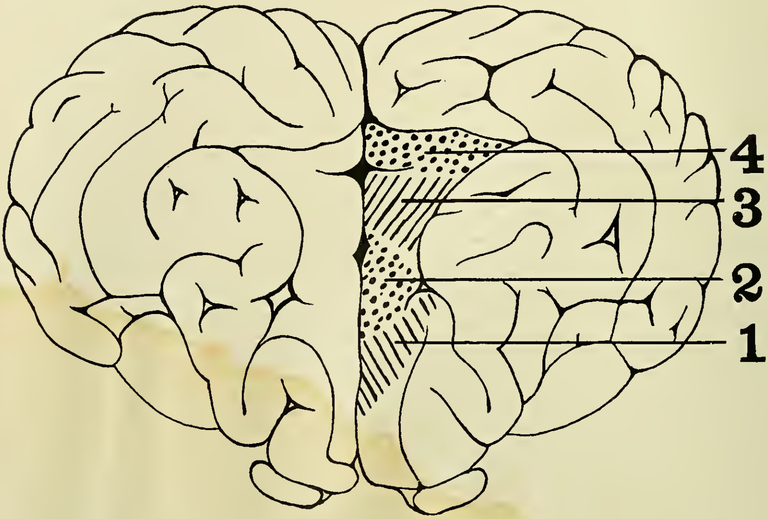

FIG. B.
Frontal elevation of the cerebrum showing the motor areas and their relations to each other.

FIG. C.
Showing the mesial surface of the left cerebral hemisphere with motor areas.

cated, but they have worked out the location of the specific centres of the various groups of muscles.

These figures show the positions of the four different centres numbered 1, 2, 3 and 4.

1. Muscles of the face, mouth and tongue.
2. Muscles of the head and eye.
3. Muscles of the fore limbs.
4. Muscles of the hind limbs.

Their locations should be marked in on the drawings that are made of the cerebral gyri and sulci, not forgetting the area involved on the facies medialis cerebri.

CHAPTER IX.

DORSAL SURFACE OF THE CEREBELLUM.

As the hemisphaeria cerebri diverge (Plate V) by the opening of the caudal extremity of the fissura longitudinalis cerebri, we see the cephalic elevation of the *facies cerebelli dorsalis.*

In the centre will be seen a large and more or less interrupted ridge called the vermis cerebelli with its surface marked by numerous transverse sulci situated quite close together and separating the narrow folia cerebelli.

The *vermis cerebelli,* as viewed from the dorsal aspect, appears to run in a caudal direction, reaching a plane almost as high as the facies cerebri dorsalis; it then turns suddenly ventrad to reach the dorsal surface of the medulla oblongata, where it turns again and takes a cephalic direction, where the convexities of the folia lie against the dorsal surface of the medulla oblongata.

These folia are very flat portions of the cerebellar substance, and are composed, like other parts of the brain, of substantia grisea and substantia alba. The former lies on the two surfaces and the convexity of each folium. Deep fissures extend down between the several folia carrying the substantia grisea with them to the bottom. When these folia are cut transversely, as in the sagittal section of the vermis, a very beautiful tree-like arrangement of grey and white matter is seen, called the arbor vitae, as shown in Plate VIII, and described in this and in Chapter XIII. The large thick limbs can be seen diverging from the central white substance, the corpus medullare cerebelli; and from these limbs smaller branches spring like the branching of a tree.

If the cerebellum be detached from the rest of the encephalon the cephalic portion of the vermis will also turn ventrad and then caudad; the apices of the vermis thus come close together, and in many specimens touch, as they lie suspended in the cavity of the ventriculus quartus.

The vermis can be divided into five lobes by four fissures. According to Bradley* the fissures enumerated in a cephalo-caudad direction may be called, fissure I, fissure II, fissure III and fissure IV, and the lobes A, B, C, D and E (Plate VIII).

In the ventral part of the concavity on the cephalic surface of the vermis will be seen a distinct horizontal fissure called fissure I, Plate VIII. That portion of the vermis vertral to this fissure is lobe A; the major part of which is characterized by such short folia that it may be called the vermis cerebelli minor; furthermore, this particular part is separated from the remainder of lobe A by quite a distinct fissure. Near the centre of the oblique cephalic surface will be observed a well marked and sharply curved fissure with its convexity directed dorsad; this is fissure II.

Lobe B lies between fissures I and II. About 5 cm. from the dorsal extremity of the caudal surface is fissure III.

Lobe C occupies the space between fissures II and III. On the ventral surface of the remaining portion of the vermis is fissure IV, separating lobes D, and E (Plate VIII).

A section of the vermis cerebelli minor is very clearly shown in Plate XXX, in Fig. 3. The caudal extremity of this portion of the vermis can be seen by depressing the medulla oblongata.

On either side of the vermis are the *hemisphaeria cerebelli;* on an ordinary inspection the facies cerebelli lateralis (Plate VI) might be said to present for examination three well marked lobes separated by two fissures. These lobes, in a general way, follow the same general arcuate course as the vermis, arching dorso-caudad and then ventrad, and may be named, lobus superior, lobus medialis, and lobus inferior. This simple arrangement, however, will be found greatly modified on a closer inspection and no small degree

**On the development and homology of the mammalian cerebellar tissues.* By O. Charnock Bradley, M. B., Professor of Anatomy, Royal Veterinary College, Edinburgh. Journal of Anatomy and Physiology Vol. XXXVII, 1903.

of complexity exists, particularly in the ventral portion of the hemisphere.

At the extreme ventral part of each hemisphere is a small lobule made up of six or seven folia, called the *flocculus* (Plate VI). Between the flocculus and the lobus superior is a long serpentine lobe called the *paraflocculus*. The paraflocculus is said to be separated from the lobus superior by a distinct fissure, but there are many instances in the mature specimen where the caudal extremity of the lobus superior appears to be continuous with the paraflocculus. The three or four cephalic folia of the lobi superiores are in direct continuity across the vermis.

CHAPTER X.

LATERAL SURFACE OF THE CEREBRUM.

The *facies lateralis cerebri* (Plate VI) of the hemisphaerium cerebri does not present the same regularity in the arrangement of its gyri and sulci, as is found on the facies dorsalis. In fact there are only two, the *fissura cerebri lateralis* (Sylvii), and the *fissura rhinalis* (fissura limbica of Turner), that are constant.

About 3.5 cm. caudad to the polus frontalis will be seen the fissura cerebri lateralis beginning on the facies dorsalis about 2 cm. laterad to the fissura longitudinalis, and, running directly ventrad for about 2 cm., divides into a ramus posterior and ramus anterior; the former runs caudad only a short distance and, turning sharply ventrad, ends in the fissura rhinalis where the tractus olfactorius unites with the lobus hippocampi. The ramus anterior is in most instances carried cephalad in a zig-zag manner, somewhat parallel with the external border of the tractus olfactorius.

The fissura rhinalis separates the tractus olfactorius and the lobus hippocampi from the cerebrum, and forms the dividing line between the facies lateralis cerebri, and the facies ventralis cerebri.

The cephalic extremity of this fissure ends in the sulcus olfactorius, not shown in Plate VI; the caudal termination is on the mesial surface of the cerebrum near the polus posticus.

Between the diverging rami of the fissura lateralis cerebri and the fissura rhinalis is a very constant lobe, called the *lobus centralis* (the insula, or the island of Reil). This lobus centralis at its caudal extremity very frequently presents three well-marked small convolutions, the central one of which rests in the angle formed by the diverging rami of the fissura lateralis cerebri. These convolutions extend into the substance of the hemisphere and can be easily shown by slightly elevating the ventral extremities of the gyrus sylviacus. In fact, the lobus centralis may be so depressed

that the ventral extremities of the gyrus sylviacus appear to hang over it, suggesting its partial occlusion; it is only in the older specimens that this overlapping is so well marked. In all cases, however, the rami of the fissura lateralis cerebri dip well in toward the centre of the hemisphaerium, thus cutting off the insula as a separate lobe.

The lower projecting ends of the gyrus sylviacus suggest very strongly the operculum in man; the ventral extremities of this gyrus might well be called the *operculum* in the sheep.

There will be seen in almost all encephala a large gyrus that has been mentioned several times already; this is the *gyrus sylviacus* (arcuatus). This gyrus arches over the dorsal extremity of the fissura lateralis cerebri. There is in many cases a well-marked gyrus lying parallel with and dorsal to the tractus olfactorius, the *gyrus orbitalis;* this gyrus is in some cases quite distinctly separated from the lobus centralis. Just dorsad to the cephalic ramus of the fissura lateralis, lies the *gyrus frontalis inferior;* these two gyri, are, however, generally broken up into a number of small irregular convolutions.

The arrangement of the sulci and gyri on the facies lateralis of the lobus temporalis follow no definite order that could be ascertained from a careful study and comparison of the limited number of encephala examined, and will not be further discussed at the present.

CHAPTER XI.

VENTRAL SURFACE OF THE CEREBRUM.

The *facies ventralis cerebri* (Plate VII) of the encephalon exhibits a large number of very important structures. That part of the cerebrum lying between the two sulci rhinales should be considered as the ventral surface of the encephalon.

At the cephalic extremity will be seen two large oval masses of matter placed obliquely; these are the *bulbi olfactorii*, very large in macrosmatic animals. These bulbs lie in the deep *sulci olfactorii;* their cephalic extremities turn slightly dorsad in front of the lobi frontales. Each bulbus olfactorius is attached to the cerebrum by three radices.

The radix medialis passes caudad and mediad to the facies medialis and unites with the subcallosal extremity of the gyrus cinguli; it is composed of substantia grisea, and is always well marked.

The radix lateralis passes laterad and caudad to unite with the cephalic extremity of the lobus hippocampi at its outer part; the lateral margin of the radix lateralis is directly continuous with the external border of the lobus hippocampi. These borders form the internal or ventral lip of the fissura rhinalis.

The radix lateralis is always well marked and much larger than the radix medialis; it consists of an external larger portion of substantia grisea, and an internal part of substantia alba much less in quantity than the substantia grisea.

The radix intermedia is composed entirely of substantia alba, derived principally from the commissura anterior, to be subsequently traced and described. This so-called radix does not appear on the surface of the encephalon but, on slightly elevating the bulbus olfactorius, or by dissecting away the substantia grisea which constitutes the locus perforatus anterior, as described in a later dissection the corresponding extremity of the commissura or radix is plainly seen (Plate XIX).

Between the sulcus olfactorius and the fissura longitudinalis cerebri is seen the gyrus rectus, which winds around the cephalic extremity of the sulcus olfactorius and then takes a course directly caudad, parallel with the gyrus orbitalis.

The large triangular or quadrilateral space (espace quadrilatiére of Broca) formed by the diverging radices olfactoriae, is called the *locus perforatus anterior.* It consists of substantia grisea marked by a large number of perforations, through which pass the antro-mesial and the antro-lateral arteries arising from the A. cerebri anterior and the A. cerebri media respectively to be distributed to the corpus striatum.

After a specimen has been taken from formalin and placed in water for twenty-four hours, examine the ventral surface just cephalad to the tractus opticus. In this region, a small band of substantia grisea may be seen extending from the mesial border of the lobus hippocampi near its cephalic extremity, to, and bending around onto the facies medialis cerebri. Here it blends with the subcallosal extremity of the gyrus cinguli.

Just caudad to the loci perforati anteriores is seen a crucial arrangement of substantia alba, the *chiasma opticum.*

Passing cephalad from the lateral extremities of the chiasma opticum (optic commissure) are two large nerves the nervi optici that have been cut in removing the encephalon.

Passing latero-caudad from the chiasma, are two large bands of substantia alba called the *tracti optici;* these tracts soon disappear dorsad to the lobi hippocampi, and will be traced to their destination in a subsequent dissection.

Immediately behind the chiasma opticum is a projection of substantia grisea, the *infundibulum,* which connects with the *hypophysis* (pituitary body, not shown in Plate VII, but drawn in Plate XIX). The hypophysis can be liberated from the fossa hypophyseos (sella turcica), when freeing the encephalon from the basis cranii interna, by making an incision through the dura at its attachments to the margins

of the fossa, then, by gently rupturing the bands of connective tissue that attach the hypophysis to the fossa, it can be removed without injury.

In the centre of the infundibulum is a large opening leading into the ventriculus tertius. The infundibulum appears to rest upon a triangular eminence of substantia grisea, the *tuber cinereum,* in the inverted specimen.

The caudal extremity of the tuber cinereum presents in most cases an eminence more or less bilobed, called the *corpora mamillaria* (corpora albicantia, bulbi fornicis). In some instances there is apparently but one corpus mamillare, as superficially, in these cases, there is only one eminence.

About two per cent of all the specimens studied show a distinct bilobed corpora mamillaria; quite as marked as that which obtains in the human brain, and in those of the primates. In class work, when a specimen of well-defined bilobed mamillary body is found, it should be shown to each student and then preserved in the neurological laboratory for demonstration purposes.

In the median line caudad to the corpora mamillaria is a very marked depression, the *fossa interpeduncularis* (locus perforatus posterior, pons Tarini), at the bottom of which is the *substantia perforata posterior.* The fossa is bounded on each side by large masses of white matter, the *pedunculi cerebri* (crura cerebri) composed of fibres which convey impulses to and from the cerebrum.

Rising from the ventral surface of the pedunculi cerebri and close to their internal border will be seen the *Nn. oculomotorii* (third pair of cerebral nerves). Winding cephalad from the dorsal surfaces of the pedunculi will be seen two nerves, much smaller than the Nn. oculomotorii; these are the *Nn. trochleares* (pathetici, fourth pair of nervi cerebrales). Lying between the pedunculi cerebri, close to the cephalic border of the pons, is a small quantity of grey matter, very marked in some cases; this is the nucleus interpeduncularis.

Tracing the pedunculi cerebri caudad they appear to pass under a thick transverse band of tissue, the pons (Varolii);

and at each extremity of the pons is a very large nerve, the *N. trigeminus* (fifth pair, trifacial).

Caudad to the pons is another, but somewhat indistinct transverse band of fibres, the *trapezium,* which in some encephala is scarcely perceptible, while in others it is very readily identified.

Arising from the ventral surface of the trapezium near the middle line are the *Nn. abducentes* (sixth pair) about the size of the Nn. trochleares.

Coming apparently from the lateral aspect of the trapezium are two nerves, about the size of the oculomotorii; the cephalic nerve is the N. *facialis* (seventh pair, portia dura); the caudal nerve is the *N. acusticus* (eighth pair, portio mollis).

CHAPTER XII.

THE MEDULLA OBLONGATA.

The *medulla oblongata* forms the large club-like body directly caudad to the trapezium; it gradually decreases in size until it reaches the neighborhood of the medulla spinalis, at the level of the first cervical nerve. At this point the decrease in size is very abrupt, until it attains the dimensions of the latter structure. The central nervous system is prolonged caudad as the MEDULLA SPINALIS, a long cylindrical mass of nervous matter which gives off the nervi spinales.

From the sides of the medulla oblongata, beginning just caudad to the trapezium there spring the roots of three large nerves, *N. glossopharyngeus* (ninth pair), *N. vagus* (tenth pair, par vagum, pneumogastric) and the *N. accessorius* (eleventh pair, spinal accessory). From the ventral surface of the medulla oblongata about 5 mm. from the midline, there arise eight of ten roots, which unite to form the *N. hypoglossus* (twelfth pair).

If the instructions to cut the nervi cerebrales close to their foramina of exit have been followed, there will be no difficulty in identifying the twelve pairs of cranial nerves just enumerated.

The encephalon should now be placed under water and the ventral surface carefully cleaned, removing all vessels and the trabeculae subarachnoideales.

Care must be taken NOT to remove the pia mater in making this dissection, for in so doing the attachments of the filaments, as they emerge to form the nervi cerebrales would be ruptured; thus very materially reducing the value of the preparation.

One who has removed the medulla spinalis for the first time will surely be impressed with the apparently numberless nerve filaments that attach the nervi spinales to the cord, particularly in the case of those that go to make the cauda equina. This same arrangement obtains on the

ventral and lateral surfaces of the brain stem. In this connection, note the N. oculomotorius, N. glosso-pharyngenus, N. vagus, N. accessorius and N. hypoglossus.

A very beautiful preparation can be made if the work is carefully done, particularly so if the low power of a good dissecting microscope is brought into requisition. Make drawings of the dorsal and lateral surfaces.

CHAPTER XIII.

MESIAL SURFACE OF THE CEREBRUM AND CEREBELLUM.

FACIES MEDIALES CEREBRI.

[See Plate VIII.]

Gently pull apart the hemisphaeria cerebri until the dorsal surface of the corpus callosum (a large band of transverse fibres uniting the cerebral hemispheres) is seen; place the heel of the brain-knife in the fissura longitudinalis cerebri, resting the edge of the knife on the corpus callosum. With one sweep of the knife, cut the encephalon completely through and the facies medialis cerebri is exposed.

This surface is of special interest to the medical student as its general appearance and construction more closely resembles that of the corresponding area of the human encephalon than any other of the regions that have been studied.

The *corpus callosum* is the elongated mass of white matter lying about the centre of the exposed surface and passing cephalo-ventrad. The cephalic extremity, the *genu corporis callosi* (knee), approaches to within about 2 cm. of the polus frontalis, then bending ventrad and caudad ends in the *rostrum corporis callosi.* The caudal extremity ends in a blunt club-like enlargement, called the *splenium corporis callosi.*

The mesial surface of the cerebrum very largely surrounds the corpus callosum as the central structure, and, like the other surfaces of the cerebrum, is for the most part subdivided by a number of fissures into gyri. The selection of the proper names for the various fissures and gyri exposed to view on this surface, caused considerable anxiety; and if proper respect has not been paid to the homologies, the censure must be laid to a perhaps excessive desire to pave the way for the student in medicine to grasp

the complex arrangement obtaining on the mesial surface of the encephalon of man. The various names have been selected that appear to describe in the clearest and shortest manner the conditions found on the part under consideration, and little regard has been paid to their significance from the standpoint of comparative anatomy, with the exception of some few terms selected from the anatomy of the human brain.

The well marked gyrus lying immediately dorsad to the corpus callosum is the *gyrus cinguli.* This gyrus extends through the entire length of the corpus callosum, with its cephalic extremity turning sharply around the genu corporis callosi, and proceeding caudad, follows the course of the rostrum corporis callosi, and ending on the facies medialis cerebri near its ventral border.

Frequently the radix medialis bulbi olfactorii can be very distinctly seen passing to the cephalic extremity of this gyrus. The caudal extremity of the gyrus cinguli passes around the splenium corporis callosi and unites with the caudal extremity of the lobus hippocampi..

The *sulcus corporis callosi* lies between the gyrus cinguli and the corpus callosum.

Dorsal to the gyrus cinguli there is seen a large *gyrus intermedius,* marked off from the gyrus cinguli by the *sulcus cinguli.* Occasionally this sulcus is poorly developed or it may be absent dorsal to the caudad third of the corpus callosum, and then the gyrus cinguli and the gyrus intermedius appear to fuse and form one very large convolution which occupies the major portion of the facies medialis, constituting the *gyrus fornicatus* of comparative anatomists.

That portion of the gyrus intermedia lying dorsad to the central third of the corpus callosum is usually very wide and in the majority of instances reaches to the dorsal margin of the facies medialis cerebri.

The *gyrus marginalis posterior* is separated from the caudal half of the gyrus intermedius by the *sulcus splenialis* (fissura limbica of Broca); this fissure is very constant in all mammals, even occurring in the Lissencephala

(smooth-brained). It can be traced, in almost all specimens, to the dorsal surface of the gyrus frontalis superior as a small fissure or notch, about 4 mm. cephalad to the fissura cruciata; Figs. a, b, and c and plate IX. The gyrus passes well cephalad in the sheep's brain and ends about the centre of the dorsal margin of the facies medialis.

The *sulcus parolfactorius* lies between the cephalic portion of the gyrus intermedius and the corresponding margin of the facies medialis, marking off the *gyrus marginalis anterior.* In a number of instances the sulcus parolfactorius is not well developed, but is broken up into numerous straight sulci, having a tangentical relation to the sulcus cinguli.

The sulcus splenialis, the sulcus cinguli, the sulcus corporis callosi and the fissura rhinalis end on the tentorial surface of the hemisphere.

The facies medialis cerebelli can be nicely seen while studying the corresponding surface of the cerebrum, showing the lobes of the vermis cerebelli as indicated in Plate VIII by the letters *a, b, c, d, e.* This dissection also shows the cut surfaces of those structures that lie ventral to the pallium.

As before noted, the radix medialis bulbi olfactorii can be seen approaching the gyrus cinguli. About 1 cm. caudad to the tip of the rostrum corporis callosi and a little ventrad, is the *commissura anterior* composed of substantia alba, cut across. This commissure is easily identified, and can be traced to the corresponding bulbus olfactorius if desired, as shown in Plate XIX. The dissection of the entire commissure will be described in a later part of the work.

Caudad to the commissure is the pars tecta columnae fornicis, the dissection of which will be described later.

This will be a convenient place to describe the cephalic and ventral walls of the ventriculus tertius, as formed by the lamina terminalis and the tuber cinereum. If the facies medialis cerebri be carefully examined, an indistinct layer of tissue can be demonstrated, extending caudad in a zig-zag manner from the terminal extremity of the

rostum corporis callosi to the comissura anterior. This layer of tissue is called the lamina rostralis, and is semi-diagramatically shown in Fig. D. It is difficult to demonstrate in most specimens.

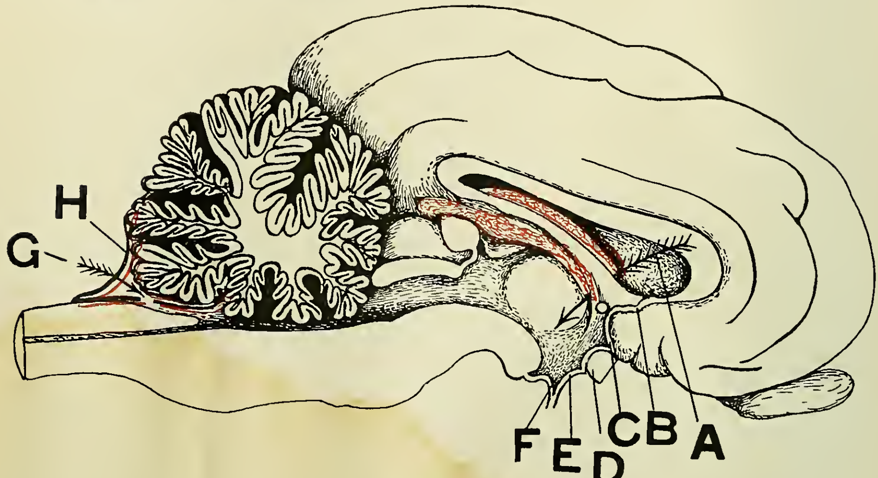

FIG. D.

A. The arrow passing through the foramen interventriculare (Monroe) accompanying the plexus chorioideus ventriculari lateralis.

B. Lamina rostralis.

C. Lamina terminalis.

D. Chiasma opticum.

E. Tuber cinereum.

F. Recessus infundibuli.

G. Arrow pointing to the aperatura mediana ventriculi quarti (Magendie).

H. Arachnoidea.

As the lamina rostralis reaches the cephalic border of the commissura anterior, it blends with the dorsal portion of the lamina terminalis (*lamina cinerea*), a structure of considerable importance. The lamina terminalis is carried almost perpendicularly ventrad to the region of the chiasma opticum, passing some little distance cephalad to the chiasma. It is then reflected backward, attached closely

to the ventral and caudal surfaces of the chiasma, forming a little cavity or diverticulum called the recessus opticus ventriculi tertii.

After the lamina leaves the chiasma it is continued caudo-ventrad as the tuber cinerea to reach the corpus mamillare. The tuber cinerea dips ventrad, carrying with it a diverticulum from the ventriculus tertius called the recessus infundibuli, to reach the hypophysis as it lies in the fossa hypophyseos. The portion of nerve tissue that passes ventrad to reach the hypophysis is the infundibulum; it, together with the tuber forms part of the floor of the ventriculus tertius.

Ventral to the splenium corporis callosi rests the caudal extremity of the fornix and beneath this, the *fasciola cinerea;* beneath the fasciola is the central portion of the fissura transversa cerebri, containing the pia and the V. magna cerebri.

Just ventrad to the fissura transversa cerebri are two small structures, the *trigona habenulae* and caudad to this the *corpus pineale;* ventrad from this latter structure is the *lamina pineale.*

Directly caudad to the corpus pineale are two pairs of bodies of unequal size, the *corpora quadrigemina*, resting on the *lamina quadrigemina, cephalad* to which is seen very indistinctly the *commissura posterior.*

Ventral to the lamina is a canal leading from the ventriculus tertius to the ventriculus quartus; this is the *aquaeductus cerebri* (aqueduct of Sylvius, iter a tertio ad quartum ventriculum).

Filling in the space which separates the commissura anterior from the commissura posterior is a large round surface of *substantia grisea,* the mesial surface of the thalamus opticus of the corresponding hemisphere. This structure forms a considerable portion of the lateral wall of the ventriculus tertius. A small quantity of the substantia grisea of one thalamus stretches across the cavity of the ventriculus tertius and is attached to a corresponding portion of the opposite thalamus forming the massa intermedia

(*commissura medialis*); the cut surface of the massa is almost circular in outline and about 1 cm. in diameter.

Posterior to the corpora quadrigemina and the pallium is seen the cut surface of the vermis cerebelli showing the arrangement of the substantia alba and the substantia grisea called the *arbor vitae.* The central portion, consisting of substantia alba, has been named the *corpus medullare cerebelli.*

Connecting the corpora quadrigemina with the corpus medullare cerebelli is a delicate layer of tissue, the *velum medullare anterior* (tegmentum ventriculi quarti, superior medullary velum, valve of Vieussens).

The *ventriculus quartus* is a large space lying ventrad to the velum medullare anterior and the cerebellum.

Leading from the caudal extremity of the ventricle will be seen a small opening the *canalis centralis* of the medulla spinalis; this canal is sometimes called the *ventriculus medullae spinalis,* and it extends throughout the entire length of the cord.

Lying ventrad to the ventriculus quartus are the following structures cut sagittally, in order cephalo-caudad; caudalic extremity of the penduncculus cerebri, together with the pons, and the medulla oblongata.

The structures enumerated as pertaining to the facies medialis cerebri must be identified and a drawing made that will embrace all of them. A comparison with the corresponding surface of the human encephalon should also be made.

CHAPTER XIV.

CEREBRAL SUBSTANCE AND THE CORPUS CALLOSUM.

The internal architecture of the encephalon of the sheep in a large number of parts is surprisingly similar to the encephalon of man.

Make an horizontal section across both hemisphaeria cerebri on a level with the highest point of the vermis cerebelli. A very beautiful arrangement of the substantia alba and the substantia grisea is presented and illustrated in Plate X.

The depth to which some of the fissures and sulci sink into the substantia hemisphaeria cerebri should be carefully noted, as well as the thickness of the substantia grisea which is quite uniform throughout.

Study the fissura cerebri lateralis, the fissure coronalis, and the sulcus splenialis which runs in an irregular manner well cephalad into the lobus frontalis, almost parallel with the fissura longitudinalis cerebri.

Examine also the long band of substantia alba that runs from the lobus frontalis to the polus occipitalis; this band is very irregular in outline, and becomes larger as it passes caudad. This appearance is formed by cutting off transversely the ventral layer of fibres of the corpus callosum and a large number of fibres of the corona radiata. These two structures will be again referred to.

Owing to these gyri and sulci the total quantity of the cortex is much greater than that appearing on the surface.

It will also be noticed that leading into each gyrus there is a band of substantia alba. This substantia alba consists of medullated nerve fibres that carry impulses to and from the cortical cells which lie in the substantia grisea.

Take one of the portions of the cerebral substance that has been cut off and tear through the exposed substantia alba toward the convexity of the gyrus, and the white substance will split in the direction in which the fibres run.

This shows very plainly how the nerve fibres, as they enter a gyrus, are distributed to its cortex.

In the further dissection of the encephalon, frequent use of this tearing process should be made for the purpose of showing the direction taken, or the ultimate termination of many definite strands of fibres, where the scalpel would imperil the success of the dissection.

When a drawing of the horizontal section has been made, the fissura longitudinalis cerebri should be gently opened. At its cephalic extremity, the fissure will be seen to pass completely through between the hemisphaeria cerebri to the ventral surface of the encephalon; likewise, at the caudal extremity, the fissure will pass completely through the cerebrum.

In the central portion, however, the fissure is interrupted by a very large band of transverse fibres of substantia alba, already mentioned, called the *corpus callosum*. A section of this structure has been noticed on the facies medialis encephali. The corpus callosum is the *great commissure* of the cerebrum.

Tear away as carefully as possible the gyrus cinguli, lying dorsad to the corpus callosum and examine its exposed surface (Plates VIII, XI, XII, XIII). The transverse direction of its fibres can be clearly seen after the gyri cinguli have been removed, yet all the fibres do not run transversely; for in the centre of the corpus callosum, passing in a sagittal direction will be observed two strands, the *striae longitudinales mediales* (nerves of Lancisi).

Between these longitudinal striations is a very distinct furrow running parallel with them called the *raphé*. External to the stria longitudinalis medialis on either side, there is another striation, the *stria longitudinalis lateralis* lying directly ventral to the gyrus cinguli. This latter stria fades out before reaching the genu corporis callosi, and on its backward extension fuses with the caudal extremity of the lobus hippocampi. The stria longitudinalis medialis can be traced cephalad around the genu corporis callosi to the crura corporis callosi; traced caudad they pass over to the ventral surface of the splenium corporis

callosi and become continuous with the fascia dentata by way of the fasciola cinerea.

In the central portion of the corpus callosum, its fibres assume the transverse direction, but as they proceed laterad they diverge quite acutely and form what is called the *radiatio corporis callosi.* Those fibres constituting the genu, and many adjacent fibres, bend in a latero-cephalad direction toward the polus frontalis forming what is called the *forceps anterior* or minor, which together constitute about three-fifths of a circle.

The fibres of the rostrum radiate ventrad and are directed toward the corresponding border of the facies medialis of the lobus frontalis. The fibres constituting the splenium (Plates XI and XII) take a curved caudad direction to reach the polus occipitalis, forming the *forceps posterior* or major, following very closely the radiating distribution assumed by the fibres of the genu in the lobus frontalis; some fibres of the corpus callosum are seen to pass dorsally to the lateral side of the cornu posterius ventriculi lateralis, and then proceed cephalad to the extremity of the lobus hippocampi as shown in Plates XII and XVI. This arrangement appears to be similar on the two sides, though it is somewhat difficult to follow. The direction of these various bands of fibres of the corpus callosum can be demonstrated by tearing in the direction in which they run. Trace carefully, and describe the arrangement of the fibres of the genu and the rostrum by drawings.

The *tapetum* is a layer of tissue forming the roof of the cornu inferius ventriculi lateralis, and the cornu posterius ventriculi lateralis when present. It is derived from the corpus callosum, and is described in the human encephalon.

In the angle where the gyrus cinguli fuses with the ventral surface of the corpus callosum, will be found a longitudinal band of association fibres, called the *cingulum superius* (cingulum, a girdle).

This cingulum lies within the cortex, dorsal to the corpus callosum and can be easily distinguished from the stria longitudinalis lateralis; it is most readily found where the

gyrus cinguli meets the corpus callosum. This tract is quite narrow where it rests upon the corpus callosum, but increases in size as it passes cephalad and caudad. Traced cephalad it spreads out like an open fan, and, following the fibres of the genu, is distributed to the region of the apex of the lobus frontalis. Following the tract caudad, it can be traced around the caudal border of the splenium, passing ventrad, and then cephalad to end apparently in the substantia alba of the lobus hippocampi.

The strand should be dissected out before completing the study of the fibres of the splenium, the fibres of which tear very nicely to their termination in the cortex of the gyri at the caudal extremity of the pallium.

A drawing is to be made showing the general shape of the corpus callosum, with the central longitudinal fibres; the drawing to likewise show on one side the lateral fibres, and on the opposite side the cingulum superius.

Make a sagittal incision through the cephalic two-thirds of the corpus callosum just to one side of the stria longitudinalis medialis; the knife will be found to enter a large cavity, the *ventriculus lateralis* (Plate XIII). The corpus callosum will be seen to form the roof of this portion of the ventricle. The genu corporis callosi, and the rostrum corporis callosi as they turn ventrad and caudad, form respectively the cephalic boundary and the extreme cephalic portion of the floor of the ventricle. A portion of this arrangement is shown in Plate VIII.

Pull away in an outward direction the cut fibres of the corpus callosum, and expose the cavity of the ventricle. At the outer angle of the ventricle, and attached to the ventral surface of the corpus callosum, is another band of longitudinal fibres called the *fasciculus subcallosus* (cingulum inferius).

The fasciculus subcallosus (Plates XII and XVI) is very distinct from any of the other structures found in the ventriculus lateralis. The fibres of this fasciculus, moreover, are very closely attached to the ventral surface of the corpus callosum, but the fibres of the two structures do not in any way intermingle.

The structure is exposed by very gently elevating the fibres of the corpus callosum with a pair of blunt pointed forceps; this operation had better be commenced in the region of the caudal extremity of the ventricle, where the fasciculus is quite distinct and well developed. This fasciculus begins at the cornu anterius ventriculi lateralis as a very slender band of substantia alba, which in some instances can with difficulty be traced—attached to the nucleus caudatus—cephalad and ventrad to the substantia perforata anterior; or it may run into the radix olfactorius intermedia.

An earnest effort should be made to accomplish this dissection, as some variation in the cephalic termination of the fasciculus subcallosus may be ascertained. As the fasciculus is traced caudad it becomes wider and thicker, forming a very graceful band having the shape of the italic letter *f;* passing dorsad to the caudal extremity of the corpus striatum, the plexus chorioideus ventriculi lateralis, the hippocampus, and the dorsal portion of the cornu inferius ventriculi lateralis. Traced farther caudad, it passes between the fibres of the splenium, and those of the cingulum superius, and finally spreads out in a radiating manner to be distributed to the caudal extremity of the pallium.

Particular attention must be given to the manner in which the caudal extremities of the cingulum superior, the splenium, and the fasciculus subcallosus are related to each other. The fasciculus subcallosus forms a very small portion of the roof of the ventriculus lateralis along its lateral aspect; and as it passes cephalad it winds around the nucleus caudatus. Traced caudad it forms more of the roof of the ventricle and when it arches over the cornu inferius ventriculi lateralis it is quite wide and easily identified.

The ventral surface of the fasciculus subcallosus is covered by the ependyma which lines the general ventricular cavity of the encephalon, while its dorsal surface is in contact with the substance of the corpus callosum, and the substantia alba of the overlying pallium.

The cingulum superior and the fasciculus subcallosus, are structures that may be called *association bundles,* because they connect different regions of the same hemisphere. Some of these bundles are quite long, connecting for example, the polus anticus with the polus posticus; while other bundles may be very short, connecting contiguous gyri. These association bundles contain both corticifugal and corticipetal axones.

Make another incision in the corpus callosum, parallel to that already made, exposing the one ventricle and 2 mm. to the opposite side, leaving a small strip of corpus callosum in the middle line; carefully reflect the corpus callosum just cut through, from over the remaining ventriculus lateralis, and the two ventricles will be clearly exposed to view. Now proceed to open the whole of the body of the ventricle, by removing the remaining portions of the corpus callosum except the central sagittal strip, the genu, and above 4 mm. of the splenium.

CHAPTER XV.

THE LATERAL VENTRICLES.

The *ventriculi laterales* (Plates XIII, XIV, XV, XVI, XVII, XXVI fig. 2, XXVII, and XXVIII figs. 1 and 2) are two symmetrically arranged cavities, one for each hemisphærium. These ventricles are large irregular cavities lined with ependyma, a species of epithelium derived from the original cell layer of the embryonic neural tube. This ependyma lines all the ventricles of the encephalon and is reflected over the pia mater and the plexus chorioideus that lie in these cavities, and, at the caudal extremity of the ventriculus quartus, it becomes continuous with the ependyma lining the canalis centralis of the medulla spinalis.

Each ventriculus lateralis is about 3 cm. long, 8 mm. wide, and about 6 mm. at its greatest depth. The roof is formed principally by the transverse fibres of the corpus callosum; the fasciculus subcallosus, however, as previously stated, enters in a small measure into the formation of the roof of the ventricle at its caudo-lateral portion. Its cephalic wall is formed by the genu. The mesial portion of the caudal extremity of the ventricle in the middle line is lost in the angle formed by the union of the fornix with the corpus callosum, while the lateral portion is carried ventro-laterad as the cornu inferius ventriculi lateralis.

The floor of the ventricle is very irregular and is formed by the following structures: *Caput nuclei caudati, plexus chorioideus ventriculi lateralis, corpus fornicis,* and *hippocampus.*

Filling in the concavity of the genu corporis callosi, is a thin membrane, the *septum pellucidum,* which separates the two ventriculi laterales toward their cephalic extremities. The septum pellucidum is thin and translucent, and extends from the inner concave surface of the corpus callorum to the *columnae fornicis anteriores.*

In an occasional specimen the two layers which go to

make the septum pellucidum, can be demonstrated, with a very narrow space intervening; the so-called fifth ventricle or pseudocoele. This *cavum septi pelludici* is located in the cephalic part of the septum close to the columnae fornicis. A small vessel can be seen in this cavity, which is derived from the vessels on the ventral surface of the encephalon.

In most instances, however, the septum is so thin that it appears to consist only of the double layer of the ependyma. In several specimens, however, the ventral part of the septum pellucidum could be seen to consist of two layers of tissue, between which was a very narrow slit-like space, that extended for some distance caudad.

Leading from the main cavity of each ventriculus lateralis are two quite large prolongations called the *cornua.*

The *cornu anterius ventriculi lateralis* projects cephalad, ventrad, and somewhat laterad around the cephalic extremity of the caput nuclei caudati to its ventral extremity, where, turning sharply cephalad, it enters the tractus, and passes thence to the bulbus olfactorius to form the *ventriculus bulbi olfactorii.*

The *cornu inferius ventriculi lateralis* is in reality the continuation, ventrad and cephalad, of the caudo-laterad extremity of the ventricle. This cornu toward its termination bends mediad, and terminates opposite a point on the ventral surface of the encephalon where the tractus opticus passes dorsad to the lobus hippocampi.

Passing into this cornu are seen the *hippocampus, fimbria hippocampi* (tænia hippocampi), *fascia dentata,* and the plexus chorioideus ventriculi lateralis (Plate XVI).

The portion of the encephalon forming the outer wall of the descending cornu should be removed from one side, exposing the entire cavity and its contents, care being taken not to disturb the hippocampus and the plexus.

At the caudal extremity of the ventriculus lateralis, where the hippocampus takes a sharp turn ventrad, there can be seen in most instances, a shallow cavity pointing caudad; this depression is, in all probability, a poorly de-

veloped cornu posterius ventriculi lateralis, so well developed in the human encephalon.

In the further consideration of the ventriculus lateralis, it would be well to study the structures lying in, or forming the floor of the cavity.

The intraventricular portion of the *corpus striatum* called the *nucleus caudatus*, is the large pear-shaped projection more readily seen in the cephalic extremity of the cavity. It is composed of substantia grisea covered by the ependyma lining of the ventricle. Over its convex surface are seen quite a number of large veins that meet near the union of the middle and caudal thirds of its inner border, forming one large *vena terminalis*, into which empties the V. chorioidea.

The V. terminalis leaves the ventriculus lateralis through the *foramen interventriculare* (foramen of Monro, porta) (Plates XIII, XIV, XV and Fig D), and enters the ventriculus tertius where it becomes the *V. cerebri interna*.

The further course of this vein will be followed when the structures of the ventriculus tertius are considered.

The internal arrangement and relationships of the structures forming the corpus striatum will be exposed and studied after the other prominent features of the ventriculus lateralis have been considered.

At the point where the V. terminalis dips ventrad to reach the foramen interventriculare will be seen a triangular space called the *recessus triangularis;* this space is very apparent if the corpus fornicis and the nucleus caudatus be slightly separated.

Lying against the caudal two-thirds of the internal surface of the nucleus caudatus is the *plexus chorioideus ventriculi lateralis*, a very dense vascular fringe formed on the margin of that portion of pia mater which pushes the very thin wall of the ventricle before it during development, and finally occupies the fissura transversa. On superficial examination this plexus appears to lie within the ventricular cavity of the encephalon though morphologically it is outside of it.

This process of pia as it rests over the third ventricle is

called the *tela chorioidea ventriculi tertii* (velum interpositum).

The plexus chorioideus ventriculi lateralis, traced cephalad, apparently leaves the ventriculus lateralis passing into the ventriculus tertius by way of the foramen interventriculare; then proceeding caudad on the ventral surface of the tela, it forms the *plexus chorioideus ventriculi tertii.*

Now note particularly, that at every point in its course, the plexus chorioideus is always covered by the thin ventricular wall which is not visible to the naked eye, and always morphologically outside of both the foramen interventriculare and the ventricle.

Reflect the sagittal strip of corpus callosum remaining after exposing the ventriculi laterales, and the fornix will be seen; in removing this strip, do not in any way molest the genu. The septum pellucidum can now be very nicely seen (Plate XIV), stretching between the genu corporis callosi and the columnae fornicis; examine the septum carefully at this stage and see if two laminæ can be demonstrated. Tracing the plexus chorioideus ventriculi lateralis caudad and laterad, it will be seen to pass ventrad, accompanying the cornu inferius ventriculi lateralis and following the concave border of the hippocampus almost to the extremity of the cornu.

The plexus receives its arterial supply from the ramus posticus of the A. cerebri propria and from the A. cerebri posterior.

CHAPTER XVI.

THE FORNIX.

The *corpus fornicis* (L., fornix, an arch) (Plates XIII, XIV, XVI, XX, XXVII) is a large body of substantia alba, triangular in shape, and attached to the ventral surface of the caudal half of the corpus callosum.

Stretching along either side of the fornix is the plexus chorioideus ventriculi lateralis.

At its cephalic extremity the fornix is continued as two large cords of tissue called the *columnae fornicis* which dip ventrad and then caudad to end in the corpora mamillaria, as shown in Plate XX.

The course of these columnæ will be shown when working out the structures on the facies medialis cerebri.

The central portion of the corpus fornicis runs caudad between the dorsal extremities of the hippocampi, forming the *commissura hippocampi.* Some fibres at the cephalic extremity of the commissura hippocampi run in a sagittal direction, filling in the angle formed by the diverging crura fornicis posterioria (posterior pillars of the fornix) as they approach the hippocampi. These sagittal fibres, on reaching the caudal border of the splenium, divide into two bundles, one proceeding toward each polus occipitalis cerebri.

Pick up some of these mesial sagittal fibres of the fornix and tracing them caudad, they will be seen to diverge, and run with the transverse fibres of the splenium.

No little difficulty will be experienced in tracing the fibres of the various fasciculi of the fornix even if great care is exercised in making the dissection. Furthermore, some fibres will be found to unite with the substantia alba of the hippocampi.

The marginal strands pass latero-caudad to reach the concave borders of the hippocampi, where they are called the *fimbria hippocampi* (corpus fimbriatum, tænia hippocampi), along which they can be traced almost to the

extremity of the ventricle (Plates XIV, XVI, XXVIII). As each fimbria runs into the cornu inferius ventriculi lateralis, it gradually diminishes in size and is finally lost on the free concave border of the hippocampus.

The student should take ample time to study the relationship of the fornix to the surrounding structures, as well as its attachments with the hippocampi and the corpora mamillaria. Note the exact position of the columnae fornicis in their relations to the commissura anterior, the ventriculus tertius, the foramen interventriculare and the ventriculi laterales.

The continuity of the columnae fornicis with the corpora mamillaria will be worked out in a later dissection.

Make special note of the relative position of the following structures; corpus callosum, fornix and velum interpositum, and their proximity to the ventricles.

CHAPTER XVII.

THE HIPPOCAMPUS.

(Plates XIII, XIV, XVI, XXI, XXII, XXVIII)

The hippocampus is a large curved cylindrical body formed by the *fissura dentata* (Plate XVII) projecting into the caudal portion of the ventriculus lateralis and its cornu inferius; it begins in the caudal third of the floor of the ventricle, and at once passes into the cornu. Its direction at its beginning is latero-caudad, but it changes its course very abruptly and dips into the cornu inferius almost vertically; toward its termination it changes its course again, running in a cephalo-mediad direction, and ends at the extremity of the cornu inferius ventriculi lateralis, at about the cephalic pole of the lobus hippocampi.

The substantia grisea of the lobus hippocampi can now be traced around the ventro-mesial border of the lobe to its inner surface.

At this stage of the dissection make a transverse incision through the cephalic extremity of the corpus fornicis just at the dorsal end of the foramen interventriculare. Make another incision through the tractus olfactorius where it joins the lobus hippocampi using the side of the encephalon where the external wall of the cornu inferius has already been removed in a previous stage. Now proceed to elevate the corpus fornicis and the hippocampus which is cut loose from its tractus olfactorius, avoiding injury to the delicate tela chorioidea ventriculi tertii, and its plexus.

The tela will be seen to pass laterad, ventrad and cephalad, and rests in the fissura transversa cerebri. This fissure will be seen between the following structures, viz., the fornix, splenium and hippocampus dorsad and laterad, and the corpora quadrigemina, penduneuli cerebri and the thalami, ventrad and mesiad. The fissure is horseshoe-shaped and lies in a plane which cuts the horizontal at about 70°.

As previously stated, the pia mater invaginates the cavity

of the encephalon through the fissura transversa cerebri where it forms the tela chorioidea ventriculi tertii. Care should be exercised so that the location and relations of this fissure are clearly understood. If the thin wall of the encephalon, which is pushed into the ventricular cavity during development, were visible, there would be little difficulty in understanding the true relationship of the various structures in this neighborhood; and how it is that the choroid plexus is not inside the cavity of the ventricles, nor the foramen interventriculare a true foramen nor the fissura transversa a true fissure, in the sense that they open into the ventricular cavities.

In turning again to the substantia grisea of the lobus olfactorius (hippocampi) it will be seen to pass to the concave surface of the hippocampus where the fissura hippocampi (fissura dentata) lies parallel to the margin of the fimbria hippocampi; the fold of substantia grisea lying between the fissura hippocampi and the fimbia is the *fascia dentata hippocampi* (Plates XVII, XXVIII, figs. 1 and 2).

The substantia grisea which surrounds the fissura hippocampi can be traced dorsad, mediad and cephalad where it finally ends in the *fasciola cinerea.* (Plates VIII, XVIII, XXVIII, fig. 1) close to the middle line where only a narrow slit separates it from the fasciola of the opposite hippocampus. The fissura hippocampi can be distinctly traced to, and around the dorsal extremity of the fasciola to its mesial surface where it ends. Each fasciola is thus divided into a dorsal part continuous with the fascia dentata, and a ventral part continuous with the substantia grisea of the hippocampus. None of the fibres of the fimbria can be traced to the ventral portion of the fasciola. Pick up some of the fibres of the ventral surface of the fornix, and many can be traced very nicely, to the fasciola cinerea and the substantia grisea of the fascia dentata; while the fibres of the fimbria hippocampi are distinctly distributed to the fascia dentata only.

Turn the severed hippocampus over to the opposite side together with the fornix; this will expose the tela chorioidea

ventriculi tertii lying dorsad to the caudal half of the ventriculus tertius.

At the cephalic extremity of the tela the Vv. cerebri internæ unite to form a large central vein, the *V. cerebri magna* (vein of Galen) (Plates III, XIV) which runs directly caudad to the middle line of the tela, over the corpus pineale, ventral to the central line of the splenium corporis callosi.

At this point the vein rests in the sulcus separating the fasciolae cinereæ, then passing caudad about 1.5 cm. it enters the sinus sagittalis as described when studying the sinuses.

Grasp the cephalic extremity of the V. cerebri magna and pull it and the tela, caudad, in order to expose the ventral surface of the tela. On each side of this vein will be seen the plexus chorioideus ventriculi tertii.

Now replace the vena magna with the tela, and note the following structures. Mediad to the place occupied by the plexus chorioideus ventriculi lateralis on either side, will be found a large oval eminence, the thalamus; between the caudal extremities of the thalami there lies a small conical body, the corpus pineale (Plates XV and XXVII, fig. 2). Caudad to the thalami and the corpus pineale are four eminences or colliculi called the *corpora quadrigemina* (Plates XV, XXI, XXIV, and XXV). Reflect the tela from these four bodies and its continuation with the pia that is attached to the outer aspect of the encephalon can be easily understod.

The large V. cerebri posterior will be seen in the groove between the thalamus and the corpora quadrigemina; it runs dorsad and empties into the V. cerebri magna as it lies between the caudal extremities of the hemisphæria cerebri.

By gently separating the corpus striatum (nucleus caudatus) from the thalamus, the *stria terminalis* (tænia semicircularis) (Plate XVI) will be seen at the bottom of the sulcus separating these two structures. It consists of white fibres that end cephalad in the caput of the corresponding nucleus caudatus and caudad they follow the cauda of the nucleus caudatus to its end.

CHAPTER XVIII.

THE OPTIC THALAMUS.

The *thalamus opticus* (for illustrations see Plate XV) is not seen when the corpus callosum is removed to expose the ventriculus lateralis. In order to see it, the plexus chorioideus lateralis must be pulled toward the fornix, and the edge of the latter structure somewhat elevated; this maneuver will expose the thalamus very clearly, and show at a glance its relations to the corpus striatum, fornix and plexus chorioideus.

In the human encephalon, the thalamus is exposed to view as soon as the corpus callosum is removed.

At the present stage of the dissection, however, the free surfaces of the thalami are nicely exposed, with the exception of the mesial; which, however, was identified and briefly described when studying the facies medialis cerebri (Plate VIII).

As can readily be seen, a large part of the cephalo-mesial surface of one thalamus is attached to the corresponding part of the mesial surface of the opposite thalamus, forming a bridge across the cavity of the ventriculus tertius; this can be the better seen if a very slight effort, not sufficiently violent to rupture the connection, be made to separate the two thalami. This bridge consists of substantia grisea, and is called the massa intermedia, the so-called middle commissure—a misuse of the term commissure.

Near the mesial border of the dorsal surface of each thalamus will be seen the stria medullaris thalami to be described later. The thalamus appears to terminate caudad in a large projection or tubercle called the *pulvinar* (tuberculum thalami posterius). A similar protuberance, though smaller and much less prominent can usually be seen on the cephalic extremity of the thalamus which has been named the *tuberculum thalami anterius*, to which can be traced the fasciculus thalamomamillare at its dorsal extremity.

Just beneath the pulvinar and a little laterad is the *corpus geniculatum internum*. The *corpus geniculatum externum* (Plate XXXVIII) will be noticed in close relation with the corpus geniculatum internum lying directly cephalad and a little dorsad, the point of the line O (Plate XXI) shows the location of this body which is very indistinct in fresh specimens.

In a subsequent dissection, after the structures exposed in Plate XXI have been studied, cut deeply into the tractus opticus and the corpora geniculata at right angles to the surface, the direction of the incision to pass through the tips of the lines G and F. This section will expose the substance of the two geniculate bodies and show them separated by only a very thin layer of substantia alba. This substantia alba appears to form more or less of a capsule that in many instances can be observed to completely surround the substantia grisea of the external geniculate bodies.

Later, the tractus opticus will be traced to the pulvinar, the corpus geniculatum externum and to one of the cephalic pair of the corpora quadrigemina (colliculus superior). We may now revert to a brief consideration of the corpus striatum together with a short study of some of the arrangements of the constituents of the thalamus.

Make a horizontal section through the entire hemisphærium cerebri to which the lobus olfactorius is still attached, just dorsad to the sulcus rhinalis, carrying the incision to the middle line with one sweep of the brain-knife and study the structures exposed as shown in Plate XVIII.

The substantia grisea of the nucleus caudatus is easily identified; external to this is a more or less interrupted band of substantia alba, the *capsula interna*.

Beginning at its cephalic extremity this capsule is directed mediad and caudad, until it reaches the sulcus lying between the thalamus and the nucleus caudatus; at this point it makes a bend called the *genu capsulæ internæ* and then proceeds laterad and caudad as a dense white band ending finally in the substantia alba of the occipital extremity of the hemisphere.

That part of the capsule lying cephalad to the genu is called the *pars frontalis* (anterior limb), while that portion caudad to the genu is the *pars postica* (posterior limb).

Lying directly external to the capsula interna is the *nucleus lentiformis* (nucleus lenticularis). In many cases this nucleus lentiformis can be seen to be composed of an external dark portion, the *putamen*, and an internal part, lighter in color, called the *globus pallidus*.

External to the nucleus lentiformis is seen a very thin band of substantia alba, the *capsula externa*, connecting the substantia alba of the lobus frontalis with the substantia alba of the lobus occipitalis.

Laterad to the capsula externa is the *claustrum* (CLAUDERE, to shut), an irregular band of substantia grisea; varying in amount and in some specimens difficult to demonstrate.

Lying immediately outside the claustrum is the substantia alba, very small in quantity, and the substantia grisea, very considerable in quantity, of the insula. The substantia grisea of the insula is cortical matter, and is directly continuous with the general cortical substance of the encephalon.

The surface lying internal to the pars postica of the capsula interna, is the cut surface of the thalamus, consisting of substantia alba and substantia grisea arranged in a very interesting manner as follows:

The substantia alba is centrally located, shaped like a triangle, the sides of which are slightly concave, and which might be called the *pars centralis thalami*. The pars centralis divides the substantia grisea of the thalamus into three distinct areas; the *area medialis thalami*, the largest of the three portions of the substantia grisea, which lies between the pars centralis thalami and the mesial surface of the thalamus; the *area lateralis thalami* is between the pars centralis thalami and the pars postica of the capsula interna; the *area posterior thalami* is located directly caudad to the pars centralis thalami, forming the caudal extremity of the thalamus and enters largely into the formation of the pulvinar.

The area posterior thalami is occasionally very plainly divided into two portions of nearly equal size by a sagittally directed process of substantia alba derived from the pars centralis and extending caudad.

The arrangement of the substantia alba and the substantia grisea just described can be very nicely seen if the encephalon be prepared by the Kaiserling method.*

In this description of the gray and white masses of the thalamus, no attempt is made to homologize them with the several nuclei of the thalamus opticus of man.* (**)

The instructor should prepare a number of encephala

The Kaiserling Method.—A method for "wet preparations" of the central nervous system for museum and demonstration specimens. It results in a specimen tough enough to resist much handling, and at the same time one in which both the normal size and especially the color are retained to a remarkable degree. It is well adapted for pathological specimens, whether of nervous or other tissue.

Special Reagents Required.

A. *Fixing and hardening fluid*—

Formalin (40 per cent formaldehyde)	cc.	200
Distilled water	cc.	1000
Potassium nitrate (saltpetre)	grams	15
Potassium acetate	grams	30

B. *Preserving fluid*—

Potassium acetate	grams	200
Glycerine	cc.	400
Distilled water	cc.	2000

The formulæ as given will result in fluids sufficient in amount for a human brain, provided the vessels used are small enough.

Procedure.

1. The brain or spinal cord is removed and placed in a vessel containing enough of the fixing fluid A to cover it well, keeping it in the dark for from six to eight days.

It is advisable to inject about 400 cc. of the fluid through the internal carotid artery before removing the brain, especially if there is reason to believe that post-mortem softening has begun. Do not inject too much, lest the blood, and consequently the color, be washed out of the blood-vessels.

The bottom of the vessel should be padded with absorbent cotton, and during the period of fixation, the position of the specimen should be changed from time to time to prevent flattening or distortion.

2. Drain the specimen for 2 or 3 minutes, and place in 95 per cent alcohol for 5 or 6 hours.

3. Then place in a glass vessel containing the preserving fluid B, where it will keep indefinitely.

Even in the preserving fluid it is advised to keep the preparation in the dark as much as possible, since the long exposure to light seems to cause it to lose its natural color.

When on exhibition or in use for study or demonstration, the preparation may be improved in appearance by placing it in 80 per cent alcohol for the time being. This seems to brighten the color to a certain extent. Too long duration in alcohol, however, will extract the color.

This process is well adapted for the preparation of specimens for dissection. If dissection is made, it is suggested that it should be delayed until after the specimen has been in the preserving fluid for about two weeks.—"Virchow's Archiv." Bd. 147, Heft. 3, p. 389. 1897.

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* (**) A very concise and clear description of the human thalamus is given by Gustav Mann, M. D. Edin., B. Sc. Oxon., in The British Medical Journal Feb. 11, 1905.

by the Kaiserling process and make the necessary dissections to show these structures for verifying the text; as brains prepared simply in formalin occasionally do not show the differentiation, or at best, somewhat indistinctly.

CHAPTER XIX.

THE PINEAL BODY.

The *corpus pineale* (L. PINUS, a pine-cone, conarium, pineal gland, epiphysis). Descartes considered this structure the seat of the soul. (Plates VIII, XV, XXV, XXVIII, fig. 1.) It is situated in the fossa formed by the colliculi superiores and the thalami.

The corpus pineale is said to contain neither neuron elements nor nerve fibres. It does contain, however, a variable amount of hard, gritty, calcareous grains or particles. Beware of this material if sectioning this organ with a fine microtome knife.

Beneath the corpus pineale will be observed quite an acute triangular depression which may be called the *fossa subpinealis*, the floor of which is formed by the lamina pinealis. Dorsal to the corpus passes the tela chorioidea ventriculi tertii and the V. cerebri magna. It is retained in position by a duplicate of pia, derived from the ventral surface of the tela. It lies dorsal to the commissura posterior.

Leaving the ventral surface of the epiphysis is a layer of substantia alba called the *lamina pinealis* (Plate XX) which passes caudad, ventral to the commissura posterior and ends in the lamina quadrigemina.

Passing across the dorsal border of the cephalic surface of the corpus pineale is a short transverse band of tissue, called the *commissura habenularum* (habena, a rein or bit) ending at either extremity in the *trigonum habenulæ*.

The trigonum habenulæ is a small depression. It marks the position of a collection of cells called the *ganglion habenulæ*. Extending from this ganglion, making a graceful curve in a caudo-ventral direction to reach the nucleus interpeduncularis, is a large and important bundle of fibres called the *fasciculus retroflexus* of Meynert. This fasciculus can be traced very easily in a serial section, stained by Pal-Weigert process; see Plate XXXVIII.

Running cephalad from the trigonum habenulæ on either side are the *striæ medullares thalami* (habenulæ); these striæ pass cephalad, resting on the dorsal border of the mesial aspect of the thalamus, then ventrad until they reach the neighborhood of the foramen interventriculare. Their further course is obscure. Between the trigonum habenula and the lamina pinealis will be seen a small space called the *recessus pinealis ventriculi tertii.*

CHAPTER XX.

THE ANTERIOR COMMISSURE.

Press the columnæ fornicis gently cephalad and you will see just in front of them, as they diverge in their course ventrad, toward the ventral part of ventriculus tertius, a large transverse cord of substantia alba, the *commissura anterior cerebri* (Plate VIII, XVII, XIX, XX, XXVII.)

Take a lateral half of the encephalon and scrape away the substantia grisea of the lobus frontalis in the region of the ventro-mesial border, and that of the nucleus caudatus, taking care not to injure the columnæ fornicis, and expose the lateral prolongation of the commissure.

By keeping to the ventro-mesial border of the commissure as the student proceeds cephalad there will be no fear of injuring any important structure in making this dissection. A special dissection is necessary to show the whole of the commissura anterior and to show its relations to the bulbi olfactorii. The requisite dissection can be made before the encephalon has been cut sagittally, without unduly mutilating the lobi frontales, as follows.

After the ventral surface of the brain has been studied and a drawing made, including the chiasma opticum with its tracti optici and the nervi optici, the search for the commissura can be undertaken. With a sharp scalpel make an incision through the centre of the chiasma in a coronal direction, as illustrated in Plate XIX. Now proceed with some blunt instrument to scrape away the substantia grisea from the loci perforati anteriores to the extent of 1 cm. on each side of the fissura longitudinalis cerebri, carrying the excavation toward the dorsal surface of the encephalon until a cord of substantia alba about 2 mm. in diameter is reached; this is the commissura anterior. The further dissection is carried on very easily when once this point is reached, for all the student has to do is to clear away the substantia grisea that surrounds the remainder of the struc-

ture, until it can be clearly traced from one bulbus olfactorius to the other.

The commissura is horse-shoe-shaped, with its centre about 1 cm. immediately dorsal to the chiasma opticum, while the limbs run cephalad, parallel to the fissura longitudinalis, and enter their respective bulbi olfactorii.

As far as could be observed from gross dissections, the commissure distributes very few fibres to any structures except the bulbi; a few, however, appear to radiate to the lobi frontales and the lobi temporales. This arrangement seems to be quite different from that obtaining in the brain of man where the major portion of the commissura anterior is distributed to the lobi temporales, and only a few fibres to the bulbi olfactorii. On no account should the study of this commissure be neglected.

With a sharp knife cut the columna fornicis, on the mesial surface of a lateral half of an encephalon, at the foramen interventriculare, and gently trace it cephalad and ventrad. At the point where the columna approaches to within about .5 cm. of the commissura anterior, it is called the *pars libera columnæ fornicis* as shown in Plate XX.

When it reaches the level of the commissura it becomes imbedded in a quantity of substantia grisea, where it is called the *pars tecta columnæ fornicis.* The columna is tough and is composed entirely of substantia alba. It passes caudad to the commissura anterior along the mesial border of the thalamus to its ventral surface to reach the corpus mamillare, where it is distributed to the substantia grisea of that body. A very nice dissection of the columna fornicis can be made by simply scraping away the substantia grisea from the mesial surface that covers the columna without cutting it.

From the substantia grisea of the corpus mamillare there rises a cord of white fibres which takes a course cephalad, dorsad and then slightly caudad, ending in the nucleus of the tuberculum anterius thalami, where it appears to end in a dense spray of white fibres that spread out and run caudad and are finally lost in the substance of the thalamus. The strand that connects the corpus mamillare

with the thalamus is called the *fasciculus thalomomamillaris* (tract of Vicq d'Azyr).

The pars tecta columnæ fornicis and the fasciculus thalamomamillaris are quite large and can be readily exposed if the substantia grisea be removed as directed. To show the fasciculus thalamomamillaris the excavation must be carried caudad until a large part of the surface of the thalamus has been removed. In no case was the fasciculus thalamomamillaris seen to be directly continuous with the pars tecta columnæ fornicis, in the substance of the corpus mamillare. In making the incision dividing the encephalon into two equal parts, the knife will occasionally deviate from the middle line as it approaches the ventral surface, and pass down through the ventral portions of the pars tecta columnæ fornicis and fasciculus thalamomamillaris, and thus expose their fibres and make identification easy.

CHAPTER XXI.

THE THIRD VENTRICLE.

The *ventriculus tertius* (diacoele) (Plates XV, XXV, XXVII, XXVIII) is a slit-like space in the central region of the encephalon, lying in the sagittal plane. Overlying it is its thin roof of velum interpositum and adherent to this is the tela chorioidea ventriculi tertii.

In removing the brain from the skull the V. magna cerebri is pulled upon and this in turn pulls in a caudad direction the tela and the plexus, and gives the impression that the ventricle is not entirely covered by this membrane as shown in Plate XIV; this, however, is not the case as the tela covers the ventricle completely.

The floor of the ventricle is formed by those structures found in the locus interpeduncularis; the frontal boundary consists of the columnæ fornicis, the commissura anterior, lamina terminalis and the caudal extremity of the septum pellucidum.

Examine carefully to see whether the cavity of the ventriculus tertius extends between the two laminæ of the septum pellucidum.

The caudal wall is formed by the corpus pineale, the lamina pinealis and the cephalic orifice of the *aquaeductus cerebri*.

The lateral walls are formed on either side by the thalami and the trigona habenulæ. The central part of the ventricle is bridged across by the massa intermedia, and at the extreme caudal extremity it is crossed by the commissura posterior. That part of the ventriculus tertius lying cephalad to the massa intermedia is occasionally called the *aula*. The ventriculus tertius communicates with each ventriculus lateralis by means of the foramen interventriculare, and with the ventriculus quartus through the aquæductus cerebri. (Plate XX.)

There is a hollow projection composed of substantia grisea protruding ventrad from the floor of the ventricle,

the *infundibulum*. This structure is about 3 mm. in length and 2 mm. in diameter, very friable and invariably injured when any effort is made to remove the hypophysis and at the same time retain its connection with the encephalon.

The *hypophysis* (pituitary body) rests in the *fossa hypophyseos* (sella turcica), and when the structures are in their normal position it is joined to the encephalon by means of the infundibulum. That portion of the infundibulum which remains attached to the encephalon after the removal of the hypophysis can be plainly seen on the ventral surface, Plate VII.

Reflect the pia mater from one of the thalami and from the ventral surface of the encephalon; then cut off one tractus opticus close to the chiasma opticum, and gradually tease the tractus away from its attachment to the pedunculus cerebri, and note its distribution to the pulvinar, colliculus superior of the corpora quadrigemina, and the corpus geniculatum externum.

CHAPTER XXII.

THE CORPORA QUADRIGEMINA.

The *corpora quadrigemina* (Plates VIII, XV, XXI, XXV and XXXVIII) are four rounded eminences lying between the thalami and the cerebellum.

The Colliculi Superiores (anterior pair, nates) are two quite large bodies, hemispherical in shape and in the sheep much greater in size than those lying directly ventral called the *colliculi inferiores* (posterior pair, testes.)

They are exposed by gently separating the cerebrum from the cerebellum. The structure of the colliculi superiores is quite complicated and difficult to demonstrate in unstained sections; much patience will therefore be required for their dissection. The cortex of these bodies is about 1 mm. in thickness, is composed largely of substantia grisea, and serves for the termination of a large number of the fibres of the tractus opticus. The deep portions of these colliculi consist mostly of transverse fibres that pass between the colliculi, forming a sharp dip ventrad beneath the sulcus inter-collicularis superior.

In sections of the mesencephalon of the sheep's brain through the colliculus superior and stained by the Pal-Weigert process and contrasted with Upson's carmine, four stratae can be distinguished with the naked eye. According to the description of the human colliculus superior, these layers would be called:

1. Stratum zonale.
2. Stratum cinereum.
3. Stratum opticum.
4. Stratum lemnisci.

The stratum opticum is largely composed of medulated fibres from the tractus opticus. If the same section is studied with the low power of a dissecting microscope, at least six distinct layers can be seen lying between the surface of the colliculus and the central grey substance.

Transverse fibres run laterad and ventrad, and pass be-

neath the fibræ pontis superficialis and finally caudad to end in nuclei situated beneath the ventral surface of the caudal extremity of the medulla oblongata. This strand of fibres can be readily teased out if the fibræ pontis superficiales have been previously removed. The colliculi superiores are separated by the *sulcus inter-collicularis superior* at the bottom of which are found two bundles of white fibres running in the direction of the sulcus, and dorsal to the transverse fibres just referred to; these sagittally directed fibres will be discussed when considering the remaining colliculi.

The Colliculi Inferiores are much smaller in the sheep than the colliculi superiores and are composed almost wholly of substantia alba. Their relations are very peculiar and interesting; to each colliculus fibres can be traced from the pars centralis thalami, passing caudad through the sulcus inter-collicularis superior, around the caudal border of the colliculus superior, where they join the substantia grisea which forms the colliculus inferior. From the lateral extremity of the colliculus inferior, fibres constituting the *brachium quadrigeminum inferius* (Plate XXIV) can be traced cephalad, resting in the sulcus between the dorsal border of the pedunculus cerebri and the colliculus superior; they then take a curved dorso-caudad direction and help to form the caudal portion of the corona radiata, and eventually are distributed to the substantia grisea of the caudal extremity of the hemisphærium.

This tract can be clearly seen if the tractus opticus be cut off close to the chiasma, and then carefully raised from the pedunculus cerebri.

In stained sections of the colliculi inferiores, the nucleus of each can be clearly seen as a round mass of matter, surrounded by medulated nerve fibres. These fibres are derived from the lemniscus lateralis of both sides of the mesencephalon. Many of the fibres can be traced dorsal to the colliculus inferior and across to the opposite side.

The fibres of the lemniscus lateralis from the floor of the trigonum lemnisci as described on page 102 and shown in Plate XXII.

CHAPTER XXIII.

CEREBRAL PEDUNCLES.

Leading caudad and ventrad from the hemisphæria are the *pedunculi cerebri* (Plate VII), emerging from the ventral surface of the encephalon between the lobi hippocampi. These pedunculi converge as they pass caudad, and meet just before they reach the cephalic border of the pons, where they disappear beneath the fibræ pontis superficiales. On their ventral surface is seen the caudal portion of the circulus arteriosus. From the ventral surface of each pedunculus, close to its mesial border will be seen arising the N. oculomotorius, from a well marked groove called the sulcus oculomotorius. Winding around the external border from the dorsal aspect, comes the N. trochlearis.

The N. oculomotorius in most animals does not emerge from its sulcus as a firm round solid fasciculus, as one would suppose from the illustrations shown in most works on human and comparative anatomy, but is formed by the union of a large number of individual fibres similar in manner to the formation of the N. hypoglossus as described on page 45.

Passing transversely across the ventral surface of the pedunculus is a very small and generally indistinct band of nerve matter called the *tractus peduncularis transversus.* This tract passes laterad about 3 mm. cephalad to the superficial origin of the N. oculomotorius, until it reaches the sulcus between the corpus geniculatum internum and the colliculus superior and thence in some rare cases can be apparently traced to the trigonum habenulæ as described in a subsequent study of the lateral area of the medulla oblongata.

On the ventral surface of the pedunculus near its mesial line is also seen a conical bundle of fibres lying in a direction parallel to the general course of the peduncle, with its apex pointing toward the pons. This mass contains the fibres of the *tractus pyramidalis,* which, traced caudad,

pass dorsal to the fibræ pontis superficiales, and emerge at the caudal border of the pons as the *pyramis ventralis* as shown in Plates XXIII, XXX, XXXV, XXXVI, XXXVII. Tracing this mass cephalad it will be seen to form a considerable part of the corona radiata; this corresponds to the genu, and the cephalic part of the pars postica capsulæ internæ, on its way to the cerebral cortex.

The apparently rapid diminution in the size of the tractus pyramidalis as it approaches the pons, is due partly to its increased thickness, dorso-ventrally, and in part to the large number of its fibres and collaterals that are distributed to the motor nuclei of the Nn. cerebrales.

A very simple procedure will show the formation of the *corona radiata* as shown in Plate XXII. Take the side of the encephalon from which the tractus opticus has been removed, and tear away the lobus hippocampi with that portion of the cerebrum lying immediately ventral to it.

In order to ascertain the direction and distribution of such fibres as those constituting in part the pyramis ventralis, pick up a small bundle and pull or tease them gently, and they will be lifted from their course very distinctly.

Make an incision passing transversely through the crura at the level of the exit of the N. oculomotorius, which incision also passes through the corpus geniculatum internum and the cephalic portion of the colliculus superior, and note the *nucleus ruber*.

No tissue resembling the *substantia nigra* of the pedunculi cerebri of the human encephalon can be found in the peduncles of the sheep's brain. In contrasted Pal-Weigert sections, groups of small ill-defined cells can be seen ventro-laterad to the nucleus ruber, where the substantia nigra would be looked for, but no pigment, granular or otherwise, could be discerned.

There are some large cells in this locality, resembling those found in the nucleus ruber, but none of these contained pigment.

Consult Plates XXIX, XXXVIII, and note how the constituent elements after they emerge from its nucleus, converge to form the N. oculomotorius and the course of the nerve fibrils from the substantia grisea ventral to the

aquæductus cerebri; also that on its way to the mesial surface of the crus it passes through a large collection of substantia grisea, the nucleus ruber.

Note the aquæductus cerebri with a comparatively thick wall of substantia grisea, and that the aquæduct is not circular. Observe also that the transverse band of substantia alba 2 mm. dorsal to the aquæduct; this band is composed of the transverse fibres of the colliculus superior. On the lateral border of this section (Plate XXIX, fig. 1, Plate XXXVIII) will be noticed a slight elevation, which is the corpa geniculatum internum and externum, and ventral to this is a much smaller elevation, very slight in some instances, representing a section of the tractus peduncularis transversus. Dorsal to the corpus geniculatum externum in the same figure is another quite small projection, a section of the brachium quadrigeminum inferius.

A section of the pedunculi, intermediate between the exit of the N. oculomotorius and the cephalic extremity of the pons is very nicely shown in Plate XXIX, fig. 2, illustrating the brachia conjunctivæ and the tractus pyramidalis pedunculi as well as the caudal extremity of the aquæductus cerebri about which are arranged four bundles of longitudinal fibres.

Plate XXIX, fig. 3, represents a section immediately cephalad to the pons showing the cephalic extremity of the ventriculus quartus and the various structures enumerated in the preceding section.

These sections are very helpful in making clear the relations of these various tracts, as well as showing clearly the composite nature of the crura cerebri. These sections should be carefully studied and drawings made. Coronal or transverse sections will be found to assist the student greatly in understanding the dissections showing the various strands and tracts.

Students should be given stained sections, through the nucleus ruber, showing the nucleus and efferent fibres of the N. oculomotorius. These should be studied and compared with the gross preparation, as shown in Plate XXXVIII.

CHAPTER XXIV.

THE PONS.

The *pons* (pons Varolii, cerebellar bridge), Plates XXIII, XXIV, and XXV, is a large band of substantia alba, lying in a coronal plane of the encephalon. Its greatest longitudinal diameter, is a little to each side of the median line where it will average about 1 cm.; at its extremities, just as it is about to enter the cerebellar hemispheres it will measure about 8 mm. The central portion of the pons is marked by a well developed *sulcus basilaris* in which rests the A. basilaris.

At the caudal extremity of this sulcus will be observed a small triangular depression, with its apex cephalad occupied by the Aa. cerebelli posteriores. The prominent convexities on either side of the sulcus basilaris mark the location of the pontal nuclei and the fibres of the tracti pyramidales. As the pyramidal tracts pass through the pons they are called the *fasciculi longitudinales superficiales pontis* (pyramidales), and can be plainly seen by making an incision in the course of the sulcus basilaris and reflecting the fibræ pontis superficialis; sections of these fibræ are shown in Plate XXX, fig. 1. This dissection, however, should be deferred until the ventral and lateral surfaces of the medulla oblongata have been studied. It will, of course, be noted that the caudal margin of the pons is quite straight while the convexity of the cephalic margin is very marked.

As the pons passes laterad on either side it takes a sharp turn dorsad and passes directly to the hemisphæria cerebelli forming the *brachia pontis* (the middle cerebellar peduncles). Rising from the lateral portions of the pons are the Nn. trigemini which are situated near the caudal margin; if the nerve be pressed caudad the fibres can be plainly seen passing between the various strands of the fibræ pontis superficiales.

Examine the nerve closely and it will be seen to consist of two bundles; that placed laterad is sensory and much

larger than the smaller or motor fasciculus placed mediad. The further dissection of this nerve will be undertaken at a later stage.

Just dorsad to the N. trigeminus is a well developed and distinct mass of cerebellar tissue, the *flocculus* (Plate XXIII).

If a specimen be prepared by the Kaiserling method it will be well to make some sections through the entire substance of the pons parallel with the transverse fibres.

This dissection will show quite plainly a deep set of transverse fibres the *fibrae pontis profundae* (Plate XXX, fig. 1) about 4 mm. from the ventral surface. These transverse fibres are quite white in color and readily distinguishable from the longitudinal fibres that have the appearance of substantia grisea. The fibræ pontis profundæ must not be mistaken for the deep transverse fibres so often mentioned as the trapeziums in works on human anatomy. In Weigert-stained sections of the sheep's brain the fibræ pontis profundæ can be clearly traced to the brachia pontis.

Besides these two groups there exist a ventral group of longitudinal fibres, the fasciculi longitudinales superficiales pontis previously mentioned; and the *fasciculi longitudinales profundis pontis* that occupy a minor portion of the dorsal two-thirds of the pons. This fasciculus is about 2 mm. ventrad to the surface of the eminentia medialis and close to the mesial line; it is often called the *fasciculus longitudinalis medialis;* this fasciculus is very distinctly seen when the section is held up to the light.

If the sectioning be made through the cephalic margin of the pons, the *brachia conjunctiva* (superior cerebellar peduncles) are very plainly seen as two pronounced folds of substantia alba at the dorso-lateral borders (Plate XXX, fig. 1).

In the midline will also be seen a distinct septum dividing the white matter of the pons into two symmetrical halves; this septum is called the *raphe pontis*. The dorsal concave surface of the pons forms part of the cephalic half of the floor of the ventriculus quartus, and the sharp

dip in the centre of this surface is the sulcus longitudinalis fossae rhomboideæ, the elevation laterad to this sulcus is the eminentia medialis; these structures will be further considered in the study of the ventriculus quartus (see Plate XXX, fig. 2).

If another transverse incision be made at the level of the exit of the N. trigeminus the two transverse fibrous masses will be seen to unite on either side and form the brachium pontis.

In sections of this region of the encephalon, the large area dorsal to the fibræ pontis, has a very irregular construction, and to the naked eye, appears to be perfectly homogeneous, except for the fasciculi longitudinalis profundis pontis. This area is the formatio reticularis; a most beautiful picture in the stained section, and a fascinating hunting ground for the neurologist.

In this connection students should be given stained transverse sections of the pons, to impress upon them a right idea of the wide distribution of the nuclei pontis. These nuclei are very extensive and have always been inadequately illustrated and described in works on human and comparative anatomy.

CHAPTER XXV.

THE TRAPEZIUM.

The *trapezium* (Plates XXIII, XXX, fig. 3, and Plate XXXVII) is a transverse band of fibres, the borders of which are nearly parallel. It occupies the space between the medulla oblongata and the pons. Its width is nearly 4 mm. and it extends completely across this portion of the encephalon.

About midway between its borders and 3 mm. from the middle line will be seen the exit of the N. abducens (sixth pair). At its lateral extremities are two large nerves, the N. facialis and the N. acusticus. The N. facialis (seventh pair, portio dura of Willis) is easily identified and arises superficially, from the cephalic half of the lateral portion of the trapezium. Its appearance is distinctly fibrillar and it passes laterad in a plane parallel with the ventral surface of the trapezium after its exit; the nerve can be readily dissected centrally toward its genu (knee) which forms the eminentia facialis situated in the floor of the ventriculus quartus, if the tissue be carefully cleared away from the lateral side of the nerve. Or, still better, make an incision through the centre of the trapezium parallel with its long diameter or parallel to the caudad border of the brachium pontis, thus making a section as shown in Plate XXX, fig. 3, and the course of the nerve can be very distinctly seen.

If the section be fortunately made along the caudal border of the nerve, it can be elevated from the surrounding tissue and traced directly to the genu. In the same section will be shown some fibres of the N. abducens passing ventrad a few mm. from the middle line. This section also clearly illustrates the large portion of the ventriculus quartus that is occupied by the vermis cerebelli minor, as well as showing the radix ascendens, N. trigemini (tractus spinalis N. trigemini) and the corpus restiforme; the two latter lying laterad to the N. facialis.

The *N. acusticus* (eighth pair, portio mollis of Willis)

is seen immediately caudad to the N. facialis and it can be traced from the tuberculum acusticum in the recessus lateralis ventriculi quarti, around the corpus restiforme lying ventrad to the flocculus. This nerve is very soft and easily torn so that considerable care must be taken in its study or it will be spoiled and the usefulness of the dissection destroyed. The course of the N. acusticus as it winds around the corpus restiforme is clearly displayed in Plates XXIII, XXIV and XXV. An elevation, well marked in most specimens, is seen on each side of the middle line of the trapezium; this is caused by the pyramis medullæ oblongatæ at the pyramis passes caudad, ventrad to the fibres constituting the trapezium, to reach the medulla oblongata.

Sections through the *trapezium*, cut in the direction of the long diameter of the *nucleus dorsalis N. cochlearis* (*N. acusticus*) and stained by Pal-Weigert process should be supplied to the student for study and drawing. (See Plate XXXVII.)

Fibres of the N. cochlearis should be traced to the nucleus dorsalis N. cochlearis, and from this nucleus other fibres are to be traced into the area acustica of the fourth ventricle, and on toward the sulcus longitudinalis fossæ rhomboideæ as the *striæ medullares* (*striæ acusticeæ*).

Another fasciculus from the N. cochlearis can be traced into the *nucleus ventralis N. cochlearis*, which lies just ventrad to the corpus restiforme and from which latter nucleus, fibres can be seen entering the corresponding extremity of the trapezium.

The *N. vestibularis* (N. acusticus) is distinctly seen passing in a dorso-mesial direction, through the substance of the brain-stem, toward the *nucleus N. vestibularis* which lies toward the floor of the fourth ventricle. This nucleus is sometimes called the "principal vestibular nucleus" or the *nucleus dorsalis N. vestibularis*.

Just mediad to the dorsal vestibular nucleus is the *radix descendens N. vestibularis*. Scattered amidst these descending fibres are large multipolar cells, easily seen with the dissecting microscope in contrasted sections. Those of

these cells that lie caudad in the radix descendens N. vestibularis, constitute what is called Deiter's nucleus, while those that are located in the caudal portion of the radix for the nucleus of Bechterew.

In each lateral half of the trapezium, 5 mm. from the raphe and quite close to the ventral surface, is a circular light area about 1 mm. in diameter, the nucleus olivæ inferior; see Plate XXX, XXXI and XXXVII. Immediately laterad to the olive nucleus is another light area, of slightly larger dimensions, containing large multipolar cells, seen in contrasted sections with the dissecting microscope, constituting the *nucleus facialis.* A wide spray of fibres visible to the naked eye in Pal-Weigert sections can be seen converging toward the eminentia facialis on the floor of the fourth ventricle, close to the sulcus longitudinalis. These fibres form the *pars prima N. facialis* (radicular part), and as they reach the floor of the ventricle just dorsad to the *nucleus N. abducentis* (Plate XXXVII), they assume a fascicular form. This fasciculus then passes cephalad for a short distance, lying mediad to the nucleus of the abducens nerve forming the *genu N. facialis* (ascending part). The nerve then turns sharply ventro-laterad to reach the surface; this is the *pars secunda N. facialis* or emerging part (fig. 3, Plate XXX).

CHAPTER XXVI.

STRUCTURE OF THE MEDULLA OBLONGATA. VENTRAL SURFACE.

The *medulla oblongata* (*medulla,* marrow; *oblongus,* greater in length than in breadth; cerebral protuberance of Goll). The lower extremity is called the "tail or rachidian bulb;" bulbus medullae spinalis seu rachidicus; French, bulbe rachidian—Dunglison; see Plates XXIII, XXIV and XXV.

In order to obtain the best results from a microscopic examination of the encephalon, the specimen should be hardened in a large quantity of a ten per cent solution of formalin for at least a month. Take the specimen from the formalin solution and place it in water for a week or two, changing the water several times; the preparation will then be in the best possible condition for inspection. In fact, the longer the material remains in the hardening solution the better. It has been found that medullae prepared by this simple method present the superficial markings much more distinctly than when they are examined immediately after removal from the skull or after a shorter immersion in formalin. The myelin sheaths of the nerve fibres swell from the absorption of water, while the connective tissue which is apparently in greater quantity between the various fasciculi, does not. This in all probability, explains the prominence assumed by the various tracts, after immersion in water, that previously were very indistinct or absolutely invisible to the naked eye.

The student will find several tracts located in the medulla oblongata very difficult to identify unless some care is exercised in preparing the specimen, but with application, and a good specimen the tracts to be enumerated can be found and named.

That portion of the encephalon under consideration is perhaps the most difficult of any of the subdivisions of the central nervous system to analyze, and nothing is at-

tempted in the present connection except the superficial markings, and those structures that are apparent in the ventriculus quartus. The nuclei of origin of the nervi cerebrales, the central nuclei, and the deep lying tracts, will not be now considered to any great extent.

It is of great assistance, however, to the student in medicine, while studying the medulla oblongata, to have several Pal-Weigert sections at hand as when studying the mesencephalon, pons and trapezium. In these stained sections many important structures can be identified without the aid, even of a hand glass, viz.: N. hypoglossus, nucleus N. hypoglossus, nucleus olivae, N. vagus, nucleus N. vagi, nucleus tractus spinalis N. trigemini, tractus solitarius, nuclei arcuati, substantia reticularis alba, substantia reticularis grisea &c.

Sections to be studied in this manner should be about 30 to 40 microns thick, thoroughly differentiated and not counterstained. If the structure of the various nuclei is to be studied the contrasted sections should be supplied as well. See Plates XXXIV, XXXV and XXXVI.

The medulla oblongata measures 21 mm. in width, 17 mm. in length and 23 mm. in thickness; those measurements will vary to a limited extent, but they are the average dimensions computed after the examination of about fifty medullae.

Before removing the pia, some attention must be devoted to the consideration of the arrangement of this membrane near the caudal extremity of the vermis cerebelli and the cephalic portion of the medulla oblongata in the region of the flocculus. Look for the aperaturae ventriculi quarti (foramen of Magendie), and examine the plexus chorioideus ventriculi quarti on either side, and note the close relation that these plexuses bear to the nervi acustici, and how they appear to follow the nerves ventrad. (Figs. D and E.)

When separating the cerebellum from the rest of the encephalon, care must be taken, not to injure the valve of Vieussens. If the valve be closely examined, a thick transverse band about 1 mm. broad can be seen within 1 mm.

of its cephalic extremity. This is the decussation of the Nn. trochleares. Grasp one of these nerves with the forceps and gently pull; it can be traced onto the margin of the valve without much difficulty. The fibres of these nerves, as they decussate, form an interlocking plait in the substance of the valve so that it is impossible to trace the nerves for any distance in the substance of the valve.

The *tela chorioidea ventriculi quarti* deserves more than a passing notice at this time. If a specimen is examined after it has been in water for a short time, and before any dissection has been attempted or before it has been handled to any extent, a clear idea of the attachments of the tela can be ascertained.

Examine the angle formed by the caudal surface of the vermis cerebelli and the dorsal surface of the medulla oblongata. Slightly depress the medulla oblongata and a comparatively dense membrane comes into view. This is a portion of the arachnoid, and is reflected from the caudal surface of the vermis and hemispheria cerebelli to the dorsal surface of the medulla oblongata where it is, in some specimens very firmly attached, as indicated by the large curved red line in fig. E, page 107. In the neighborhood of the flocculus this part of the arachnoid becomes adherent to the pia. The tela, an altogether different structure, is not at all effected by the foregoing manipulation, and cannot be studied until the caudal part of the vermis at least, has been removed, when it can be seen sagging down into the cavity of the ventricle. It forms the roof of the caudal portion of that cavity, is firmly attached to its walls, and extends cephalad as far as, and into the fissure separating the vermis major from the caudal extremity of the vermis minor.

The attachments of the tela to the walls of the ventricle are shown by the smaller curved red line in fig. E. In the immediate neighborhood of the ventricular wall it is very much thickened as shown in transverse section in Plates XXXV and XXXVI. This thickened portion of the tela is called the *ligula*.

The plexus of the tela skirts its cephalic border, and is

particularly abundant in each extremity of this border, close to the flocculus; completely filling in the angle formed by the hemispherium cerebelli, the flocculus and the corpus restiforme. The red convoluted line in fig. E shows this arrangement. A process of this same plexus passes caudad, attached to the ventral surface of the tela ventriculi quarti, hanging suspended in the cavity of the ventricle as seen in section in Plate XXXVI.

In the region where the tela is attached to the rami obicis as they form the lateral wall of the caudal third of the ventricle, they spread out into broad oval masses in section, so closely attached to the eminentia vagi (ala cinerea) that they are distinguishable only when stained. This particular arrangement will be further considered in a subsequent chapter.

Now remove the pia completely from the medulla oblongata, and in so doing the nerves will be detached, but as they have already been studied this will do no harm. In this procedure be very careful not to injure the delicate tissues that lie in the vicinity of the ventriculus quartus.

As already described the pia begins to thicken into a decidedly tough and fibrous sheath as it is traced toward the caudal extremity of the medulla oblongata, and adheres very tenaciously to the tissues inclosed. It is specially difficult to remove it from the fissura mediana ventralis of the medulla spinalis, where this structure joins the medulla oblongata.

Make an incision through the pia, parallel with, and on each side of the fissura mediana ventralis, extending to the caudal extremity of the specimen, and gradually detach the membrane towards the dorsal surface; lastly pull away the part left in the fissura ventralis. If this operation be carefully done, none of the delicate lines separating the fasciculi on the surfaces of the medulla oblongata and the medulla spinalis will be obliterated.

In Plate XXIII the pia is enlarged out of proportion, and a diagramatic space shown between the cord and pia, that does not exist in nature.

In the median line of the ventral surface is seen the

fissura mediana ventralis, extending from the caudal extremity of the sulcus basilaris to the cephalic ending of the fissura mediana ventralis medullae spinalis.

This so-called fissure of the medulla oblongata is really not a fissure, but a sulcus, the fissure having been obliterated by the decussation of the fibres of the pyramides medullae oblongatae passing from one side of the medulla to the other; clearly shown in Plate XXXIV.

On examining the medullae of nearly a hundred encephala, it was impossible to find any large bundles of fibres passing from one side of the medulla to the opposite side of the cord, a condition contrary to what we find in the human brain, where the decussating bundles are so clearly seen by the naked eye.

On either side of the sulcus ventralis is a well marked band of tissue called the *pyramis* (the anterior or ventral pyramids) which is separated from the remaining portion of the lateral half of the medulla oblongata by the *sulcus ventralis lateralis* (antero-lateral fissure); this sulcus is very distinct cephalad, but becomes very indistinct as it is traced caudad.

The pyramids are at their greatest width as they lie in the caudal part of the medulla, but as they are traced cephalad they become gradually narrower and more distinct; each tract appears to break up into strands of fibres.

The median bundles reach the caudal border of the pons, superficial to the trapezium, while the lateral bundles pass dorsad to the superficial fibres of the trapezium prior to reaching the pons, constituting the fasciculus longitudinalis superficialis pontis (see Plate XXX), where transverse sections of these bundles of fibres are nicely shown. By reflecting the fibrae pontis superficialis the longitudinal course of the fibrae pyramidales can be clearly demonstrated by tearing the fibrae in the direction in which they run. Traced caudad, the fibres of the pyramis take a dorsal direction skirting the walls of the fissura ventralis. As these fibres reach the bottom of the fissure they turn abruptly toward the opposite side, cutting across the base of the columna ventralis to reach the processus reticularis

and the region of the fasciculi longitudinales dorsales as outlined in Plate XXXIV. These decussating fibres are sometimes collected into comparatively large fasciculi or loose bundles, that can be seen with the low power of the dissecting microscope even in unstained sections. These decussating bundles are nothing in size compared to the huge bunches that cross in the human medulla oblongata.

Sections that are cut .5 mm. in thickness, when placed on the glass stage of the dissecting microscope over the black diaphragm and flooded with water, show these decussating fasciculi plainly. Or a better way is to place the freshly cut sections on dark blue glass resting on white paper and flooding with water. Now by using a focusing lense to illuminate the sections the medullated fibres become quite brilliant, and even very small fasciculi become visible.

Immediately laterad to the cephalic third of the pyramis can be found a very delicate and sometimes indistinct strip of white substance, here called the *fasciculus lateralis minor.* The cephalic extremity of this tract is first observed as it apparently emerges from the sulcus separating the pons from the trapezium; look for it just mediad to the exit of the nervus facialis from the trapezium. Occasionally considerable persistence must be exercised to identify it, but a careful search will invariably be rewarded. Traced caudo-mediad to the caudal border of the trapezium, it is seen to approach the lateral margin of the pyramis from which it is separated by a distinct depression, the cephalic extremity of the sulcus ventralis lateralis. Traced caudad it runs for a short distance nearly parallel with the fissura mediana ventralis; it then takes a gradual bend laterad to reach the lateral aspect of the medulla spinalis. In passing obliquely across the medulla oblongata it lies laterad to the exit of the fibres which unite to form the nervus hypoglossus. As the fasciculus reaches the medulla spinalis it becomes quite distinct and easily distinguishable from the adjacent tissues; it can be finally traced to the superficial area of the medulla spinalis, about

the centre of the funiculus lateralis as shown in Plate XXXIII.

There can scarcely be any question, but that the fasciculus lateralis minor is the homologue of the fasciculus ventrolateralis superficialis, commonly called Gower's tract in the human medulla spinalis. Authorities on human anatomy place this fasciculus just ventrad to the centre of the funiculus lateralis on or near the surface; but when it reaches the medulla oblongata, they bury it somewhere in the recticular formation of the medulla and pons on its way to reach the brachium conjunctivum, in the substance of which it passes to the vermis cerebelli. In the encephalon of the sheep it can be traced to the trapezium over which it passes, directing its course the cerebellum. In Pal-Weigert sections it can be seen as a compact bundle of fibres on the ventral surface just mediad to the region of the nucleus olivae. See Plates XXXV, XXXVI, and XXXVII.

Another very interesting feature of the medulla oblongata is the *oliva*, so conspicuous in the human encephalon. Lying one on each side, the olivae are to be seen immediately caudad to the trapezium, resting in the obtuse angle formed by the caudal border of the trapezium and the lateral border of the fasciculus lateralis minor. The olivae are very indistinct in some specimens, but in others again they are easily seen, and their superficial relations clearly evident.

In a transverse section of the medulla oblongata passing through the olivae, a distinct round nucleus can be seen close to the surface of the structure, Plate XXX, fig. 3, and Plate XXXI, fig. 1, also Plate XXXVI.

Laterad to the olivae on each side will be seen a longitudinal tract of considerable size traceable in some instances to the caudal extremity of the medulla oblongata. This large bundle is the *tractus spinalis N. trigemini* (*radix ascendens N. trigemini*) of the medulla oblongata and by reflecting the superficial transverse fibres of the trapezium, and the adjoining fibres of the pons, and then

teasing the nerve caudad, the fibres of this radix can be traced nicely. This radix rapidly diminishes as it is traced caudad, and toward its termination the superficial boundaries become very indistinct if not quite obliterated.

As the pia is carefully removed from this eminence a number of the radices forming the Nn. glossopharyngeus et vagus will be seen passing from the medulla between the fibres constituting the tractus spinalis N. trigemini; the direction of the line of exit of these root fibres is caudo-laterad, and they appear to be in line with those bundles of fibres that constitute the radix cerebralis N. accessorii.

Another feature of interest is the presence of a large number of arching fibres that appear to emerge from the deep tissue of the medulla oblongata by way of the sulcus ventralis lateralis. They are found on the cephalic half of the medulla, covering the caudal part of the oliva; they pass caudo-laterad then gracefully change their course to cephalo-dorsad and are lost on the surface of the corpus restiforme (Plate XXIII, Plate XXXV).

These fibres no doubt are the *fibrae arcuatae externae,* and in all probability are analogous to the striations found in the corresponding location on the human encephalon. These fibrae are somewhat difficult to find in some specimens, but they are there and a determined search will invariably reveal them. In other encephala, large numbers of these fibres reach the surface and cover a large area of the ventral and lateral surfaces, extending in some instances almost to the caudal extremity of the medulla oblongata. The fibres that are exposed on the surface form only a small part of the arciform system of fibres, as those that pass from the nuclei arcuati to the corpus restiforme beneath the surface, far exceed in number those that are on the surface. In stained sections of the medulla oblongata, just cephalad to the pyramidal decussation, great bundles of these arcuate fibres can be seen in the ventro-lateral part of the section, converging to unite with the fasciculus cerebellospinalis to form the corpus restiforme. These fibres can be seen in sections almost as far sephalad as the olivae. If sections are made through the central

third of the medulla oblongata as shown in Plate XXXV, and examined, stained or unstained, a wavy mass of apparently structureless material is seen immediately dorsad to the pyramis. These are the *nuclei arcuati,* extending for about 5 mm. on either side of the raphe where they are most extensive.

These nuclei extend throughout the middle third of the medulla oblongata, and traced cephalad they cease some little distance caudad to the olivae. It must be remembered that the arcuate fibres join those of the fasciculus cerebellospinalis and go to the corresponding cerebellar hemisphere. They are much more numerous in the sheep than in man; the nuclei likewise, are infinitely more extensive than those of the human encephalon.

This system of fibres and nuclei, obviously, has greater physiological significance in the sheep than in man; perhaps they are association centres of great complexity in structure and function; presiding over complicated systems of co-ordination and reflex acts, taking the place of the higher reflex centres in the cerebrum when these become functionless.

CHAPTER XXVII.

THE MEDULLA OBLONGATA — LATERAL SURFACE.

There is nothing particularly striking to be found on the lateral aspect of the medulla oblongata. At the caudal extremity, if the specimen be viewed from the side, the ventral surface will be seen to bend quite suddenly in a dorsad direction, to reach the medulla spinalis (Plate XXIV). The fasciculus lateralis minor is plainly seen, and will be found to be exceedingly well marked as it reaches the cord. An earnest effort should be made to identify this structure, and to determine if possible its cephalic destination. Its relations as it is traced are to be carefully noted.

Perhaps the easiest way to begin the study of the direction of the tract would be to search for it at the cephalic extremity of the medulla spinalis, whence it can be followed with comparative ease. The sulcus lateralis ventralis and the *sulcus lateralis dorsalis* are easily identified; the latter sulcus must be followed cephalad, where it will be seen lying between the tractus spinalis N. trigemini and the corpus restiforme. Toward its cephalic extremity it becomes very indistinct and finally ceases at the cephalic border of the trapezium.

Lying between the fasciculus lateralis minor and the sulcus lateralis dorsalis, is an important tract called the *fasciculus cerebellospinalis* (fig. E), because it runs directly to the corresponding cerebellar hemisphere from the medulla spinalis. This fasciculus is frequently called the direct cerebellar tract and forms part of the inferior cerebellar peduncle or corpus restiforme. Traced to its termination it will be found to pass from the dorsal part of the funiculus lateralis medullae spinalis to the medulla oblongata, constituting its lateral border resting between the tractus spinalis N. trigemini, and the cephalic termination of the fasciculus cuneatus (see Plate XXIV). Upon

reaching the lateral extremity of the trapezium, it bends dorsad, winding around the cephalic border of the N. acusticus, and then turns slightly caudad to enter the cerebellum to which it may be easily traced.

Just dorsad to the cephalic extremity of the fasciculus cuneatus will be seen a modest elevation called the *clava*, to be again referred to, and mediad to the cephalic extremity of the clava, lying close against the N. acusticus, will be observed a limited view of the *area acustica*. Note how unmistakably the N. acusticus can be observed entering the dorsal surface of the medulla oblongata.

While engaged in the study of this surface of the medulla oblongata, some very interesting structures can be investigated if the caudal third of the hemisphaerium cerebri be removed as shown in Plate XXI.

It would be well, perhaps, also to remove the hemisphaerium cerebelli and the flocculus from the side under consideration; this dissection is easily effected, and will expose the parts to be immediately enumerated as shown slightly enlarged in Plate XXIV.

Lying against the convexity of the corpus restiforme as it winds cephalad of the N. acusticus will be found a large band of substantia alba, consisting of fibres that constitute the major portion of the pons. This bundle is the *brachium pontis* (middle cerebellar peduncle) and these fibres connect the two cerebellar hemispheres. Some of these structures have been noted before but a recapitulation showing their relations to the medulla oblongata from its lateral aspect will do no harm.

A portion of these fibres may be separated from the underlying strands and traced by teasing to the medullary substance of the hemisphaerium cerebelli.

Passing caudad, beneath the cephalic border of the brachium pontis is a large band coming from beneath the corpora quadrigemina, called the *brachium conjunctivum* (superior cerebellar peduncle, anterior cerebellar peduncle, crus cerebelli ad corpora quadrigemina); this structure will be more fully described while considering the anatomy of the ventriculus quartus.

Winding from the dorsal to the lateral surface of the brachium conjunctivum can be seen the N. patheticus; this nerve is very delicate and will be torn from its attachment if the dissector is not careful, as described in Chapter XXVI while discussing the roof of the ventriculus quartus. The *brachium quadrigeminum inferius* is plainly seen running along the dorsal border of a triangular area called the *trigonum lemnisci* (Plate XXIV). The three boundaries of this space are, the ventral border of the brachium quadrigeminum inferius, the cephalic border of the pons and the dorso-caudal border of the pedunculus. Pick up some of these fibres of the leminiscus lateralis, and tear them in a cephalo-dorsad direction. They will be seen to pass between the brachium conjunctivum and the brachium pontis to the lateral extremity of the trapezium with the fibres of which they seem to be continuous. This connection between the trapezium and the lemniscus lateralis leading to the colliculus inferior is easily demonstrated in stained serial sections.

·In a later dissection when the tractus opticus has been removed, this brachium can be distinctly traced by way of the internal capsule to the caudal extremity of the hemisphaerium cerebri as shown in Plate XXII. The student must endeavor to trace this brachium when he is demonstrating the corona radiata.

At the point, where the brachium meets the pedunculus, look for the tractus peduncularis transversus, resting in the sulcus between the colliculus superior and the pulvinar. In some specimens this tract appeared traceable to the mesial surface of the colliculus superior into the sulcus intercollicularis, where it reaches the lamina quadrigemina; it then changes its course and passes directly toward the trigonum habenulae.

This tract, together with the brachium quadrigeminum inferius and the caudal border of the tractus opticus, forms another triangle, trigonum geniculatum, which contains the *corpus geniculatum externum.* As the tractus peduncularis transversus lies in the most dorsal portion of the

sulcus, it is very indistinct, but in a few encephala there can be no doubt as to its existence and destination.

The tractus opticus is particularly well shown in this dissection as it passes dorso-caudad to reach the pulvinar, corpus geniculatum externum and the colliculus superior.

If the caudal portion of the hemisphere be cut away in an oblique direction, and the dissection carefully done, the structures lying dorsad and caudad to the pulvinar will be nicely exposed and the relations of the pulvinar, fascia dentata, hippocampus, and the cornu inferius ventriculi lateralis clearly shown (Plate XXI).

CHAPTER XXVIII.

THE MEDULLA OBLONGATA—DORSAL SURFACE.

The dorsal aspect of the medulla oblongata (Plate XXV and fig. E), is of more than ordinary interest, as it is largely occupied by that interesting space called the *ventriculus quartus.* The caudal extremity of the medulla oblongata passes into the cephalic portion of the medulla spinalis quite abruptly. The greater difference will be seen in the lateral diameters. The caudal third of the medulla oblongata does not enter into the formation of the ventriculus quartus, and the description of that portion not entering into relation with the ventricle will be completed prior to the consideration of those parts of the medulla that are so intimately associated with this very important ventricle.

In the mid-dorsal line will be noticed the sulcus dorsalis continued cephalad from the cord. This sulcus is prevented from reaching the ventricle by an arched band of tissue, whose convexity is directed caudad, called the *obex,* beneath which there is a cavity called the "ventricle of Arantius."

This obex is generally quite prominent, and little difficulty will be experienced in finding it. As the sulcus dorsalis reaches the obex it appears to divide into two rami that pass latero-cephalad in opposite directions, embracing the extremities of the obex, and finally to disappear on the dorsal surface of the medulla oblongata at a variable distance from their origin.

On either side of the little triangular space formed by the obex and the diverging rami of the sulcus dorsalis, is seen a very delicate fusiform tract of substantia alba, for which I would suggest the name of *fasciculus fusiformis.* The writer's attention was first called to the possibility of a distinct tract in this region from the peculiar arrangement of the white fibres noticed in an histological section of the cord located about 5 mm. from the medulla oblon-

gata and stained with haematoxylin. The position, form, and relation of this fasciculus can be easily seen with the naked eye in almost all stained sections of the cephalic extremity of the medulla spinalis.

This tract in section is clearly shown in Plate XXXIII, P, and in making sections that gradually approach the medulla oblongata, the tract increases in size and finally reaches the surface by way of the proximal extremity of the sulcus dorsalis as illustrated in Plate XXV.

This fasciculus is scarcely perceptible in fresh encephala, and in those specimens that are examined directly after removal from the solution of formalin; after macerating the formalin-fixed brain in water for one or two weeks the tract is easily found.

If the sulcus dorsalis be gently opened the dorsal edge of the fasciculus fusiformis will be seen skirting the wall of the sulcus dorsalis, diminishing in size as it passes caudad; the dissector should not neglect to discover this fasciculus. The tract can be seen in a transverse section of the cephalic extremity of the medulla spinalis with the naked eye if a very thin section be made with a sharp knife and the section viewed while held up to the light, but not direct sunlight. It possesses a well marked nucleus that is easily identified in stained sections; see Plate XXXIV.

The sulcus dorsalis, Plate XXV, is bounded on each side by the *fasciculus gracilis* (tract of Goll, postero-internal tract), which passes cephalad and ends, when it reaches the level of the obex, in the clava which assists in forming in part the caudo-lateral boundary of the ventriculus quartus.

Laterad to the fasciculus gracilis can be seen the *fasciculus cuneatus* (tract of Burdach, postero-external tract). These two fasciculi are separated by the *sulcus intermedius dorsalis*. The fasciculus cuneatus traced cephalad ends in a very indistinct enlargement in some specimens called the *tuberculum cuneatum*. The tuberculum cuneatum is placed more caudad than the clava, as illustrated in fig. E. Within the substance of the clava and the tuberculum

cuneatum there are irregularly arranged masses of cells forming nuclei. The substantia grisea that eventually develops into the nucleus of the clava is derived from the grey matter of the cord, as an excresence growing dorsad into the cephalic part of the fasciculus gracilis, in the same manner as that of the nucleus cuneatus in the human medulla oblongata; while the nucleus of the fasciculus cuneatum develops independently. The three nuclei, viz., *nucleus fasciculi fusiformi,* nucleus fasciculi gracilis and the *nucleus fasciculi cuneati* can be seen in stained sections just caudad to the entrance of the canalis centralis into the fourth ventricle.

From these nuclei many strands of fibres, constituting the deep arciform series, can be easily seen, passing in an arched direction, ventro-mesiad across the raphe, where they turn cephalad, forming the ventral portion of the formatio reticularis alba. This band of fibres as it passes toward the cerebrum forms the mesial lemniscus or fillet as shown in Plates XXXVI and XXXVII.

These inner arching fibres can be seen in the unstained section if sufficient care and persistence is exercised.

The sulcus intermedius dorsalis is lost on the lateral aspect of the medulla oblongata. The sulcus lateralis dorsalis runs along the lateral border of the fasciculus cuneatus, separating it from the corpus restiforme, and is the line of origin of the dorsal nerve roots of the nervi cervicales as well as some of those going to the N. vagus and N. accessorius. Ventral to the sulcus lateralis dorsalis lies the fasiculus cerebellospinalis passing to the lateral area of the medulla oblongata, forming there, as stated, the major part of the corpus restiforme.

DESCRIPTION OF FIG. E.

A. Striae medullares (N. acusticus).
B. Plexus chorioideus ventriculi quarti.
C. Ramus obicis.
D. Taenia ventriculi quarti.
E. Trigonum vagi.
F. Trigonum hypoglossi.
G. Fasciculus fusiformis.
H. Obex.
I. Clava (caudal extremity).
J. Fasciculus gracilis.
K. Tuberculum cuneatum.
L. Fasciculus cuneatus.
M. Sulcus lateralis dorsalis.
N. Fasciculus cerebellospinalis.
8. Nucleus dorsalis N. cochlearis.

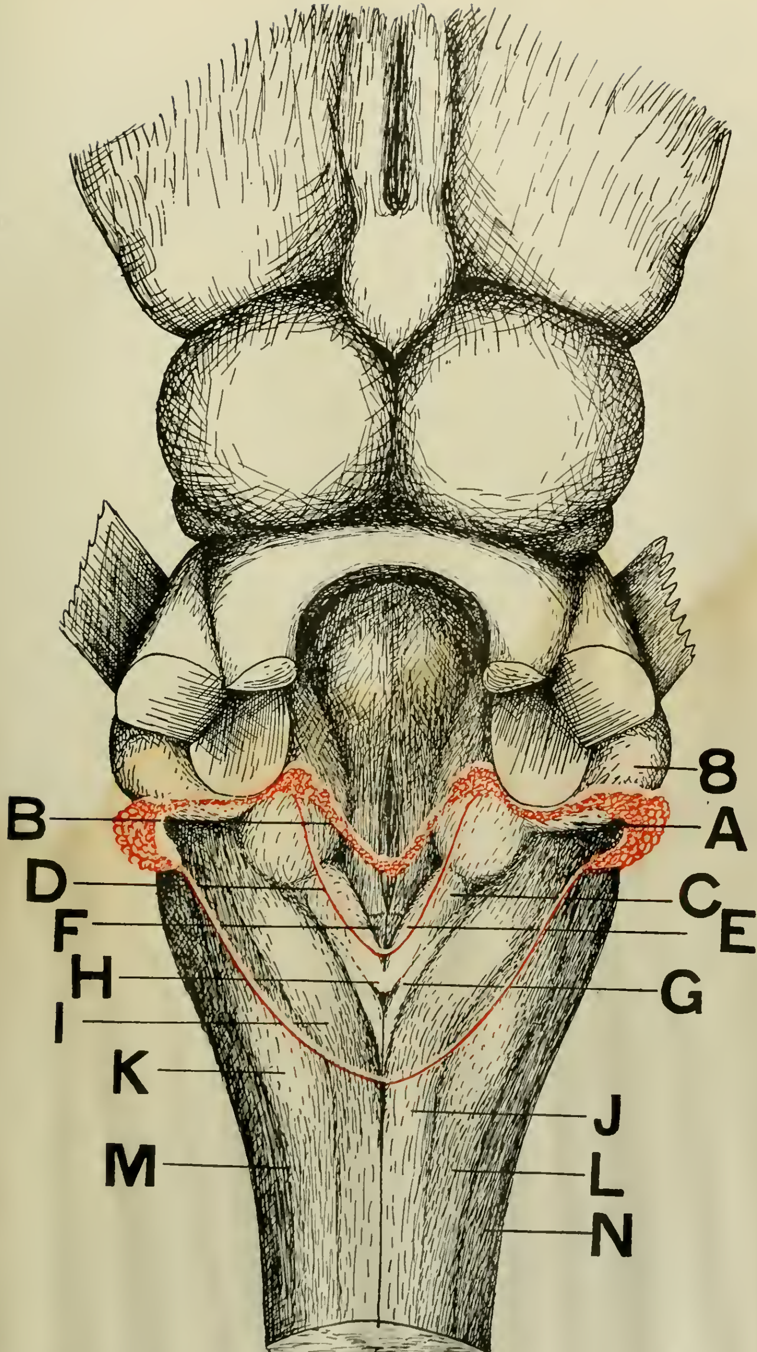

FIG. E- Showing the attachments of the pia and arachnoid to the dorsal surface of the medulla oblongata. (Description on opposite page.)

CHAPTER XXIX.

THE FOURTH VENTRICLE.

The *ventriculus quartus* (fig. E) is an irregular space lying dorsal to the pons, the trapezium and the cephalic two-thirds of the medulla oblongata. Its length is about 17 mm., its greatest width about 8 mm., and its depth 1 m. to 3 mm. Its roof is formed cephalo-caudad by the *velum medullare anterius* (valve of Vieussens), vermis cerebelli minor, and the tela chorioidea ventriculi quarti. A portion of the lateral wall at the cephalic extremity is formed on either side by the brachium conjunctivum.

The distal extremities of the brachia approach the mesial line as they pass caudad, and meet in the medullary substance of the cerebellum, forming almost a complete circle, as shown by the dotted line in Plate XXV. This circle is completely filled in or closed by the velum medullare anterius. Further caudad the lateral boundaries are formed by the areae acusticeae, and lastly by the rami of the obex and a small portion of the clava.

The *sulcus longitudinalis fossae rhomboideae* divides the floor of the ventricle into two symmetrical halves; the cephalic extremity of this sulcus leading to the caudal opening of aquaeductus cerebri, and its caudal limitation ending at the entrance of the canalis centralis into the cord.

The fossa rhomboidea is limited on each side by the *sulcus limitans fossae rhomboideae.* Just caudad to the central part of the floor of the ventricle will be seen a very narrow bi-convex area called the *eminentia medialis,* with an exceedingly shallow groove running longitudinally through its centre, perhaps a continuation of the sulcus longitudinalis fossae rhomboideae. The eminentia medialis is formed by the stria longitudinalis profundis (posterior longitudinal bundle) bending dorsad to reach the floor of the ventricle. (Plates XXXVI and XXXVII.)

This eminence in some cases is markedly depressed be-

low the floor of the ventricle and is inclosed on either side by a delicate semilunar sulcus; it is in all probability the homologue of the eminentia medialis found in the floor of the ventriculus quartus in man. The eminence is clearly illustrated in Plate XXV and Plate XXXI, figs. 2 and 3, and fig. E.

The cephalic portion of each lateral half of the ventricular floor is marked by a distinct spherical elevation called the colliculus facialis (*eminentia facialis,*) beneath which is the genu nervi facialis and to which the N. facialis can be easily traced, as shown in Plate XXX, fig. 3.

The student must not fail to make an incision parallel to the cephalic border of the trapezium extending completely through the structure in order to demonstrate the course of this nerve as it passes through the substance of this part of the encephalon.

Lateral to the eminence that has just been studied, look for a triangular depression called the *fovea anterior.* Caudad to this fovea the sulcus limitans fossae rhomboideae bends toward the middle line along the mesial border of quite a large convex elevation, the *area acustica;* note the N. acusticus leading down to it. (See Plate XXXVII.)

At the caudad extremity of the ventricle note the large mass of matter lying dorsad to the entrance of the canalis centralis, the obex previously mentioned; with its convexity directed caudad, while the rami obicis pass cephalad and are lost to view as they reach the areae acusticae. Where the inner margins of these rami meet the mesial convex borders of the areae acusticae is another triangular depression, the *fovea posterior* (ala cinerea). (See Plate XXXV.)

On each side of the caudal portion of the floor of the ventricle, lying between the sulcus longitudinalis fossae rhomboideae and the ramus obicis, is a longitudinally placed eminence called the *eminentia hypoglossi* (trigonum hypoglossi). The sulci limitantes fossae rhomboideae converge to meet the sulcus longitudinalis fossae rhomboideae at the caudal extremity of the ventricle to form the *cala-*

mus scriptorius (named by Herophilus, 3rd Century B. C.).

The nucleus alae cinereae which embraces the nucleus vagus and the nucleus glosso-pharyngeus is situated immediately lateral to the fovea inferior and the caudal extremity of the sulcus limitans fossa rhomboideae, and also, lies in part beneath the well marked elevation called the trigonum vagi or ala cinerea. Fibres from the nucleus N. glosso-pharyngeus and N. vagi can be traced to these nuclei (Plate XXXVI).

The *trigonum vagi* lies ventrad and somewhat mediad to the ramus obicis (fig. E). The line of demarcation between the trigonum vagi and the ramus obicis is often a well marked ridge which is called the taenia ventriculi quarti, or perhaps it is homologous with the *fasciculus separans* of the human brain.

The tissue lying laterad to the fasciculus separans or taenia is non-nervous; and on section has a vascular or cavernous appearance (Plate XXXV). The surface of this tissue may be called the area postrema of Retzius.

The nucleus alae cinereae, is the point of termination of the sensory fibres of the N. glossopharyngeus and the N. vagus. The nucleus ambiguus is found just laterad and ventrad to the fovea posterior, and from this nucleus spring the motor roots of the same two nerves, together with some of those of the N. accessorius.

The tractus spinalis N. trigemini can be seen 7 mm. laterad to the sulcus longitudinalis fossae rhomboideae, with its concavity, containing the *nucleus tractus spinalis N. trigemini,* directed to the mesial line. Winding around the ventral and lateral surfaces of the tractus spinalis N. trigemini is a very thick layer of fibres running in a cephalo-laterad direction to reach the corpus restiforme as shown in Plates XXXVII and XXXVIII. These fibres are plainly seen converging from the nuclei arcuati toward the corpus restiforme which forms a very prominent structure on the lateral extremity of these sections.

About 3 mm. cephalad to the tip of the calamus scriptorius, as a very slight transverse depression the *sulcus*

transversus, extending across the trigonum hypoglossi, marking off an area of tissue the shape of an isosceles triangle with its apex pointing to the entrance of the canalis centralis of the medulla spinalis.

Under no consideration must the student be permitted to leave the work on the gross anatomy of the sheep's brain without making a series of coronal sections of the encephalon such as those illustrated in Plates XXVI to XXXII, inclusive.

Drawings should be made and all the parts identified. These preparations are of great value in fixing in the student's mind the relationships of the ganglia, fasciculi and other points of interest that he has been working out in the foregoing pages.

It would be well worth the trouble to prepare a brain by the Kaiserling method, from which to make these coronal sections, for there will be difficulty in making out many of the points of interest even with a brain that has been carefully prepared.

PLATES I—XL.

[*From Drawings (Excepting I and II) by the Author*]

PLATES I AND II.

These plates represent the skull of the sheep one-half the actual size of the preparation and reproduced by photographs.

PLATE I represents the dorsal surface of the skull.

PLATE II shows very clearly the lateral elevation of the entire skull.

These two plates will assist the student in removing the brain from the cranium, by giving him some conception of the place to make the first incision, and how the further operations are to be carried on.

PLATE I—DORSAL AREA OF THE SKULL
(x ½).

PLATE II.

Lateral Elevation of the Skull.

PLATE II—LATERAL AREA OF THE SKULL (x ½).

PLATE III.

THE ENCEPHALON.

This illustration is designed to give an idea of the appearance of the encephalon, inclosed within the dura mater, the calvarium having been removed. Two of the sinuses have been opened, as they ought to be if the directions for dissecting them are carried out. Note the tubular process extending caudad over the medulla spinalis.

A. Bulbi olfactorii.
B. Triangular thickening.
C. Vena frontalis.
D. Fissura cruciata.
E. Fissura cerebri lateralis. (Sylvius.)
F. Sinus sagittalis.
G. Vena cerebri magna. (Galen.)
H. Confluens sinuum.
I. Sinus transversus.
J. Vermis cerebelli.
K. Hemisphaerium cerebelli.

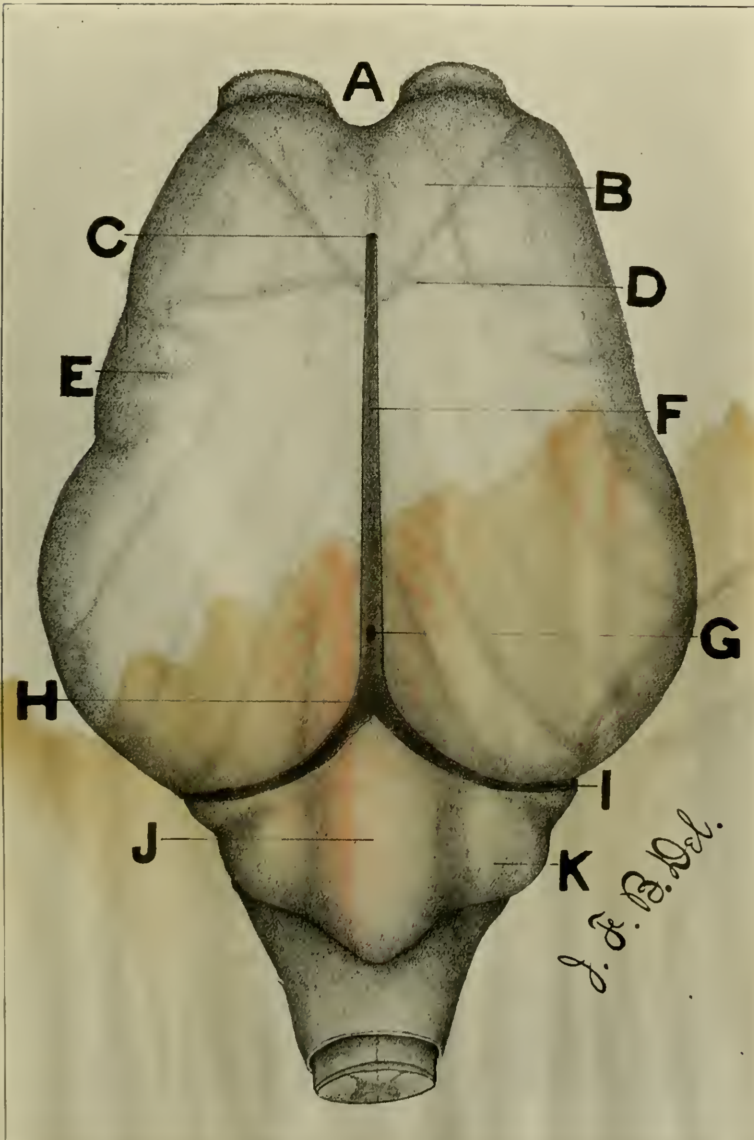

PLATE III—DORSAL ASPECT OF DURA MATER
(x 1 2/3).

PLATE IV.

THE CIRCULUS ARTERIOSUS.

The circulus arteriosus (Willisii) as shown in this drawing can be worked out on most encephala where the arteries have not been injected. It is a little difficult sometimes to identify the arteria cerebri propria because it divides immediately after entering the brain cavity.

A. Arteria cerebri anterior.
B. Arteria communicans.
C. Arteria cerebri media.
D. Ramus anterior.
E. Ramus posterior.
F. Arteria cerebri posterior.
G. Arteria basalaris.
H. Arteria cerebelli anterior.
I. Arteria cerebelli posterior.
X. Arteria cerebri propria.
Z. Arteria basilaris gangliaformis posterior.

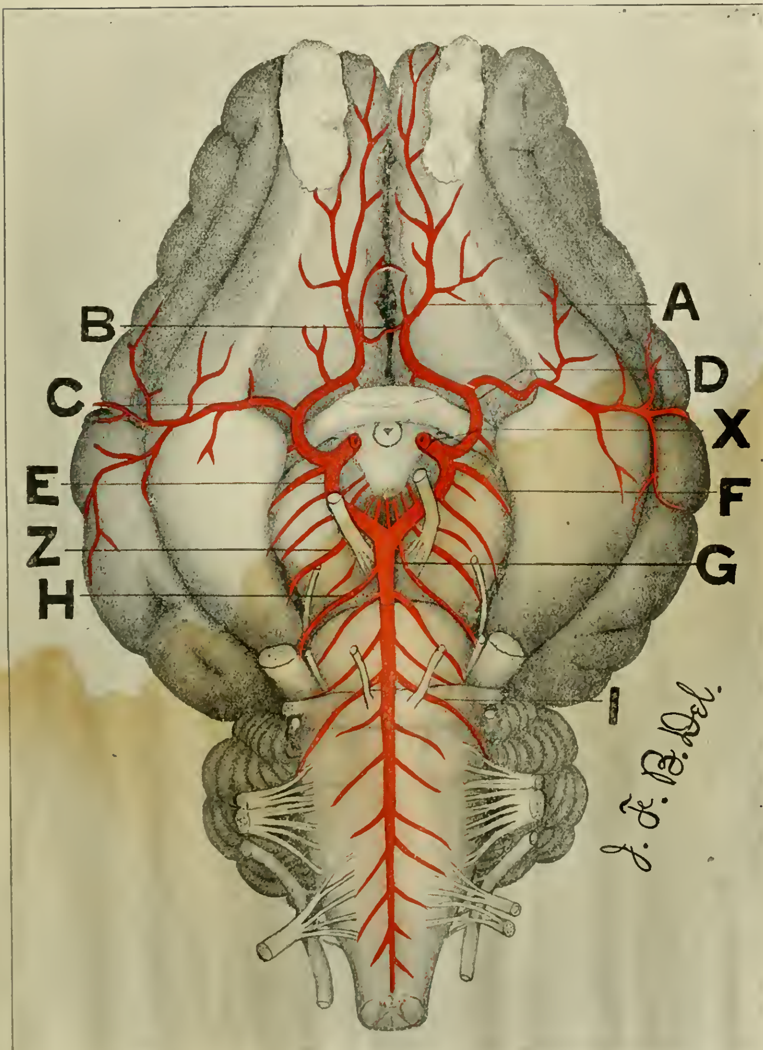

PLATE IV—ARTERIES ON VENTRAL SURFACE OF THE BRAIN (x 1 2/3).

PLATE V.

FACIES DORSALIS CEREBRI ET CEREBELLI.

A. Fissura longitudinalis.
B. Sulcus coronalis.
C. Fissura cruciata.
D. Fissura cerebri lateralis. (Sylvius.)
E. Fissura suprasylvia.
F. Sulcus lateralis.
G. Sulcus intermedia.
H. Sulcus medialis.
I. Fissura cerebelli superior.
J. Fissura cerebelli medialis.
K. Fissura cerebelli inferior.
L. Medulla oblongata.
M. Sulcus dorsalis.
Z. Polus posticus.
1. Gyrus frontalis superior.
2. Gyrus frontalis medialis.
3. Gyrus sylviacus (arcuatus).
4. Gyrus lateralis.
5. Gyri mediales.
6. Gyrus internus.
7. Vermis cerebelli.
8. Flocculus.
9. Paraflocculus.
10. Lobus superior (hemisphaerium cerebelli).
11. N. cervicalis I.
12. Medulla spinalis.

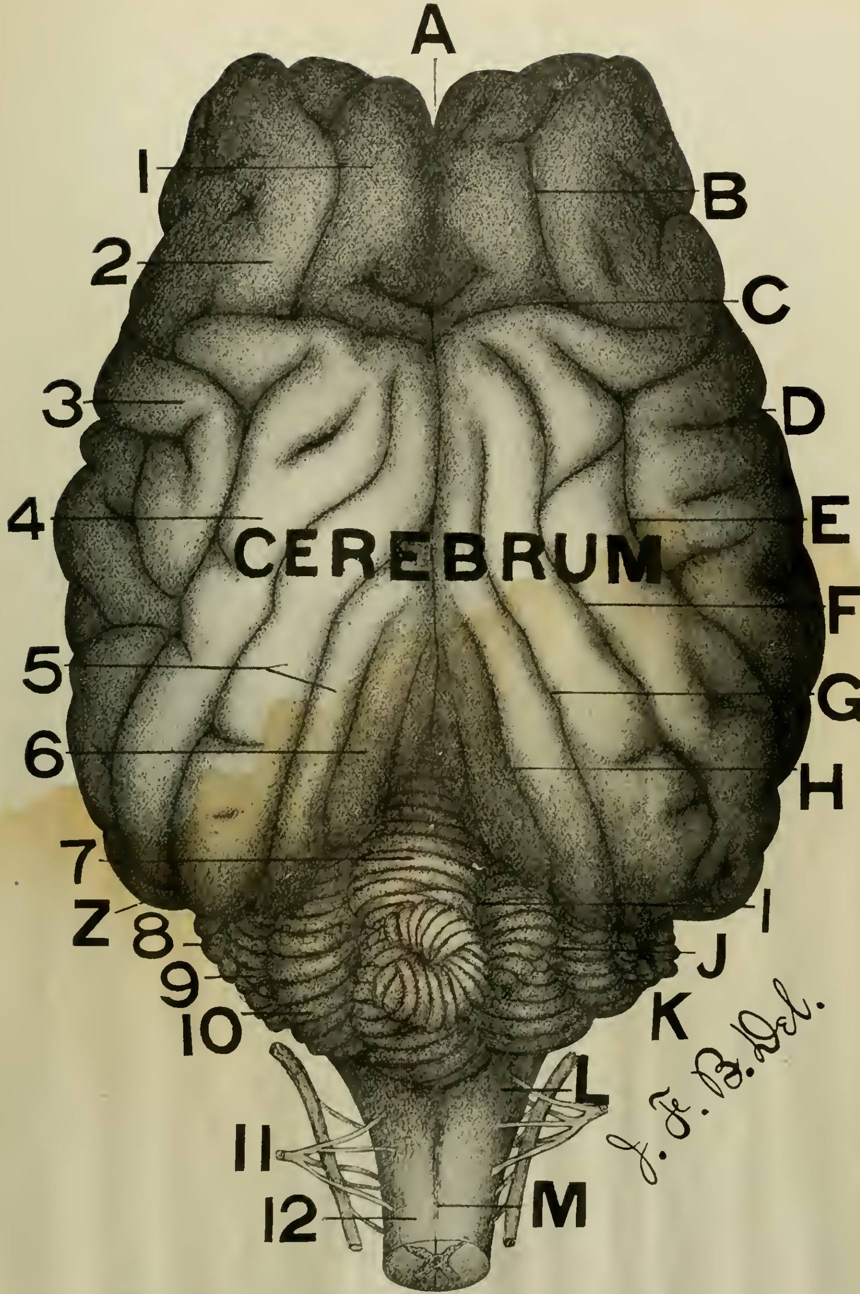

PLATE V—DORSAL SURFACE OF THE BRAIN
(x 1 2/3).

PLATE VI.

FACIES LATERALIS CEREBRI ET CEREBELLI.

A. Gyrus frontalis inferior.
B. Gyrus orbitalis.
C. Tractus olfactorius.
G. Fissura rhinalis.
H. Gyri centrales (Island of Reil).
I. Fissura cerebri lateralis (Sylvii).
J. Ramus posterior fissurae cerebri lateralis.
W. Ramus anterior fissurae cerebri lateralis.
Z. Lobus hippocampi.
3. Gyrus sylviacus (arcuatus).
7. Vermis cerebelli.
8. Lobus cerebelli inferior.
9. Lobus cerebelli medialis (paraflocculus).
10. Lobus cerebelli superior (hemisphaerium cerebelli).
11. Flocculus.

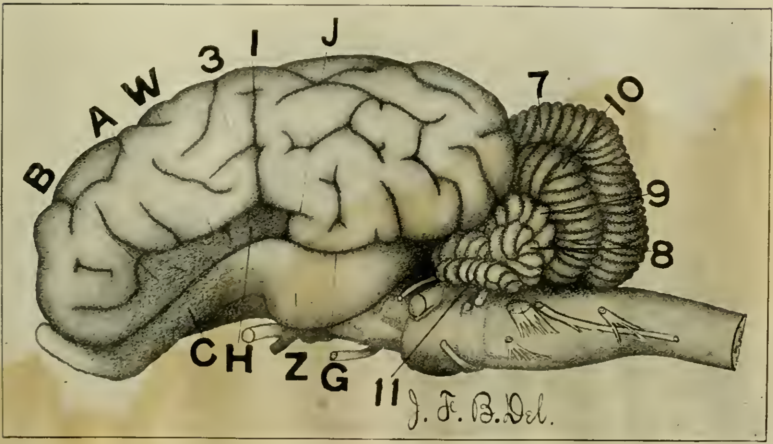

PLATE VI—LATERAL SURFACE OF THE BRAIN.

PLATE VII.

VENTRAL SURFACE OF THE ENCEPHALON.

A. Fissura sagittalis.
B. Gyrus orbitalis.
C. Substantia grisea radicis lateralis.
D. Radix medialis bulbi olfactorii.
E. Substantia alba radicis lateralis.
F. Locus perforatus anterior.
G. Fissura rhinalis.
H. Insula.
I. Fissura cerebri lateralis.
J. Infundibulum.
K. Chiasma opticum.
L. Tractus opticus.
M. Corpus mamillare.
N. Tractus peduncularis transversus.
O. Nucleus interpeduncularis.
P. Pedunculus cerebri.
Q. Pons.
R. Trapezium.
S. Oliva.
T. Fasciculus lateralis minor.
U. Medulla oblongata.
V. Radix spinalis nervi accessorii.
W. Ramus anterior fissura cerebri lateralis.
Y. Sulcus ventralis medullae oblongatae.
Z. Lobus hippocampi.
1. Bulbus olfactorius.
2. N. opticus.
3. N. oculomotorius.
4. N. trochlearis.
5. N. trigeminus.
6. N. abducens.
7. N. facialis.
8. N. acusticus.
9. N. glossopharyngeus.
10. N. vagus.
11. N. accessorius.
12. N. hypoglossus.
13. Radix ascendens N. trigemini.

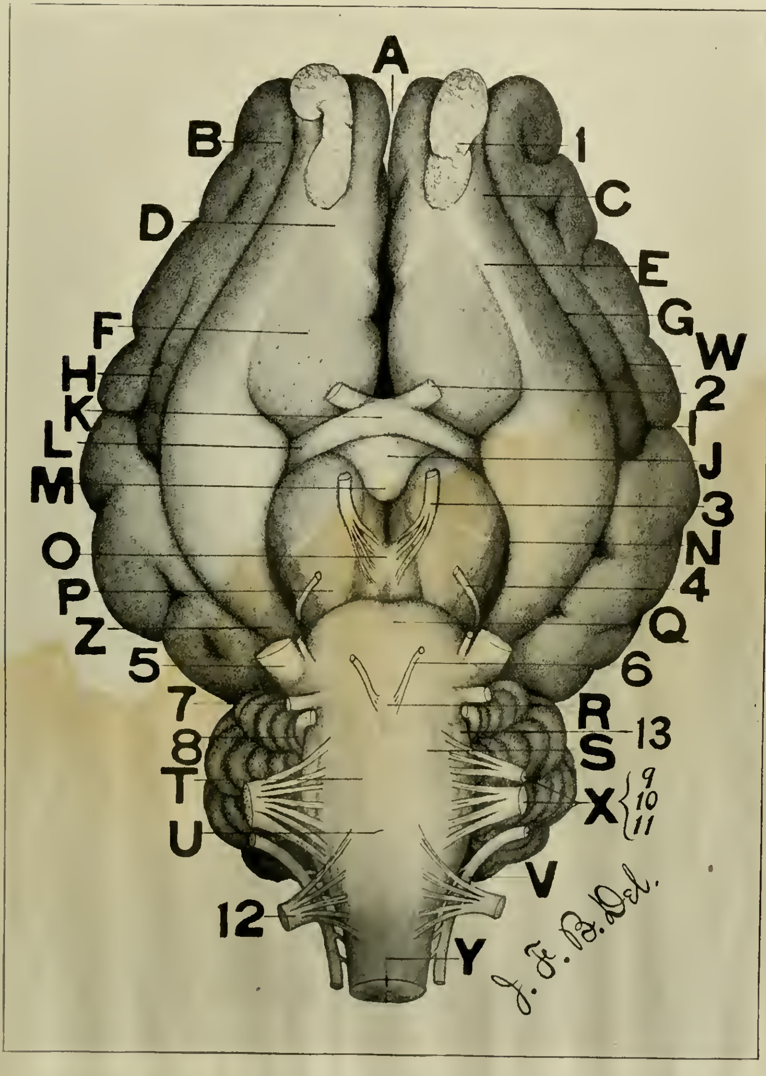

PLATE VII—VENTRAL SURFACE OF THE BRAIN (x 1 2/3).

PLATE VIII.

FACIES MEDIALIS CEREBRI.

A. Rostrum corporis callosi.
B. Genu corporis callosi.
C. Bulbus olfactorius.
D. Sulcus cinguli.
E. Gyrus intermedius.
F. Sulcus parolfactorius.
G. Gyrus marginalis anterior.
H. Gyrus cinguli.
I. Corpus callosum.
J. Sulcus corporis callosi.
K. Gyrus marginalis posterior.
L. Sulcus splenialis.
M. Splenium corporis callosi.
N. Colliculus superior.
O. Corpus medullare cerebelli.
P. Ventriculus quarti.
Q. Canalis centralis.
R. Lamina quadrigemina.
S. Corpus pineale.
T. Commissura posterior.
U. Fasciola cinerea.
V. Trigonum habenulae.
W. Corpus fornicis.
X. Massa intermedia (commissura medialis).
Y. Tuber cinereum.
Z. Commissura anterior.
2. Radix medialis bulbi olfactorii.

PLATE VIII—MESIAL SURFACE OF THE BRAIN.

PLATE IX.

FASCIES ANTERIOR.

This figure represents the encephalon when it is looked at from a point directly cephalad. This plate together with Plates V, VI and VII, will give a very clear idea of the general shape and detailed appearance of the exterior of the encephalon.

A. Gyrus frontalis medialis.
B. Sulcus coronalis.
C. Fissura cerebri lateralis.
D. Gyrus sylviacus.
E. Fissura cruciata.
F. Fissura sagittalis.
G. Gyrus frontalis superior.
H. Fissura suprasylvia.
J. Insula.
L. Lobus hippocampi.
O. Lobus olfactorius.

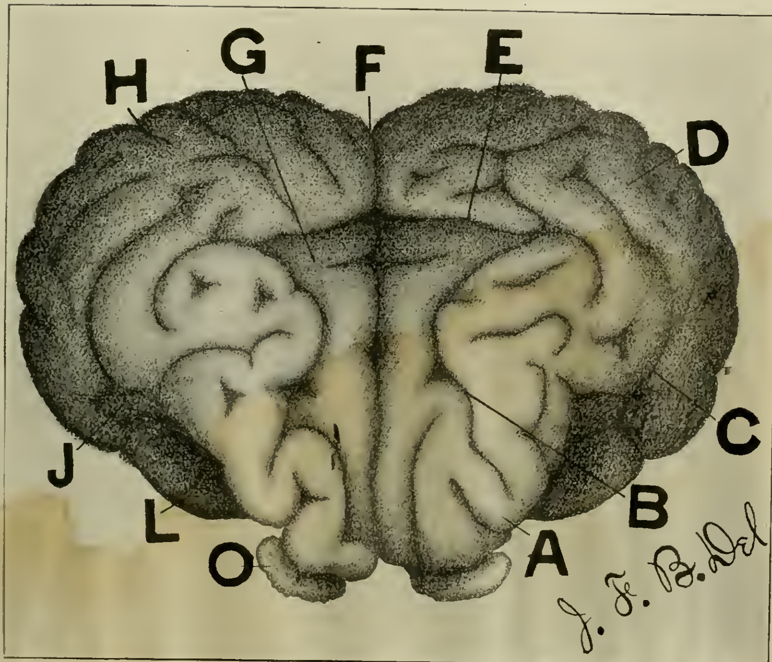

PLATE IX—ANTERIOR SURFACE OF THE BRAIN (x 1 2/3).

PLATE X.

EXTENSION OF FISSURES AND SULCI INTO THE HEMISPHERES.

This illustration is introduced to convey some idea of the relatively great superficial area provided by the extension of fissures and sulci into the substance of the hemispheres. It must also be noted that, wherever the depressions go, there follows a corresponding quantity of substantia grisea, and that this substantia grisea is composed of innumerable nerve cells, the physiological units of all nerve tissue.

It is self evident that the area thus provided affords accommodation for a vastly greater number of cells than would be possible were the surface of the cerebrum unconvoluted.

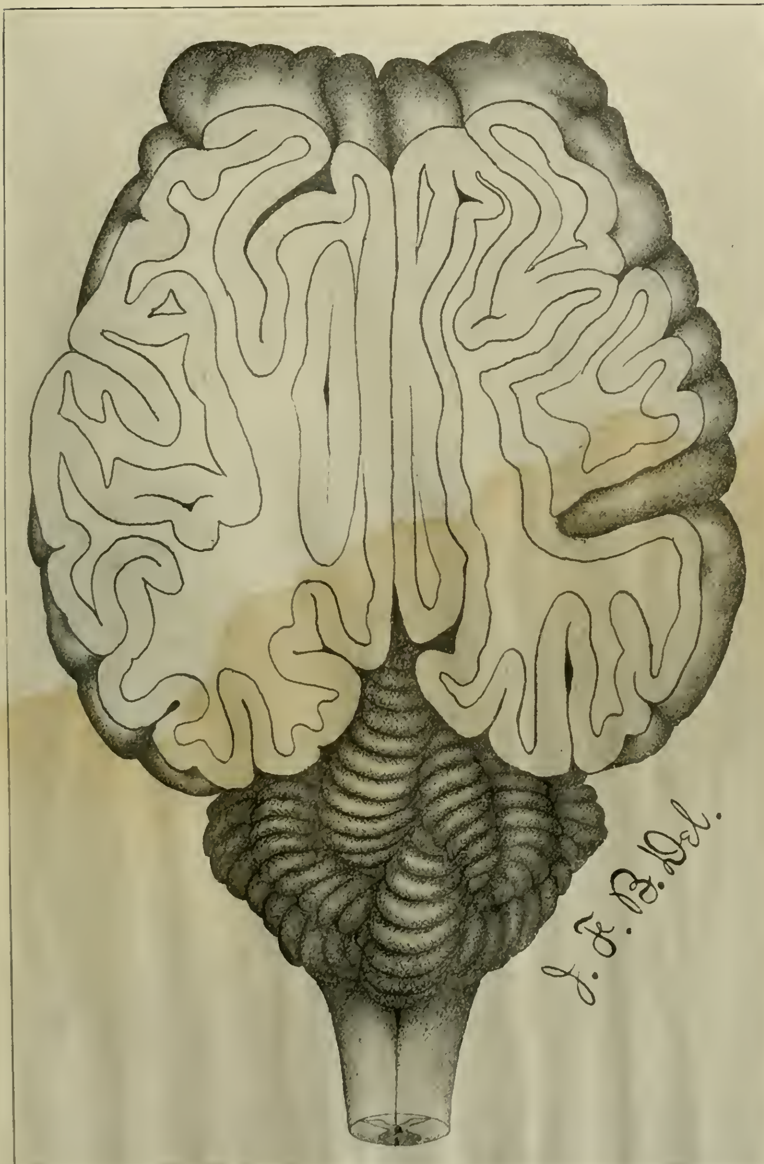

PLATE X—SECTION OF CEREBRUM TO SHOW GRAY AND WHITE MATTER (x 1 2/3).

PLATE XI.

COURSE OF THE FIBRES OF THE CORPUS CALLOSUM.

This dissection was made to convey to the student some idea of the course taken by the fibres of the corpus callosum in its various parts.

A. Genu corporis callosi.

B. Stria longitudinalis medialis.

C. Stria longitudinalis lateralis.

D. Corpus callosum.

E. Fibres of the caudal portion of the corpus callosum after they have changed their course and proceed cephalad toward the cephalic extremity of the lobus hippocampi, covering the cornu inferius ventriculi lateralis.

F. Splenium corporis callosi.

G. Corpus pineale.

H. Colliculus superior.

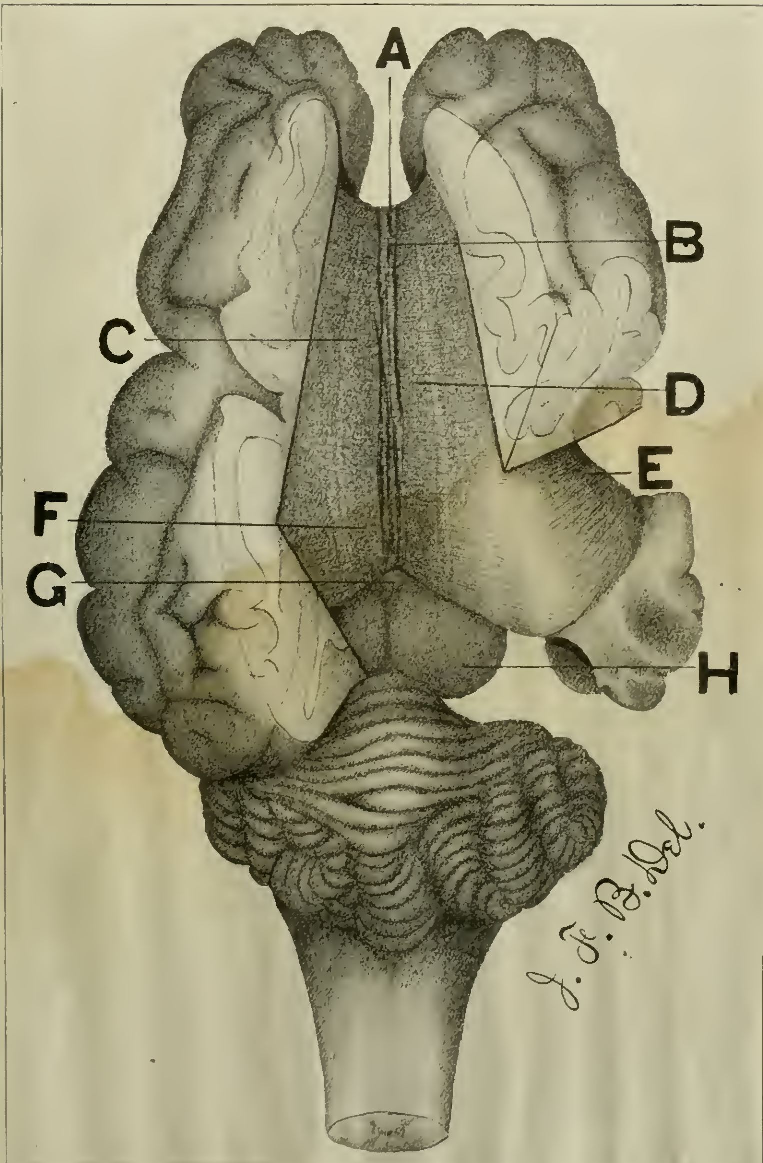

PLATE XI—CORPUS CALLOSUM, DORSAL SURFACE (x 1 2/3).

PLATE XII.

FIBRES OF THE CORPUS CALLOSUM AND STRIATED CONSTRUCTION.

Represents many features that are similar to those shown in the preceding cut, emphasizing more particularly perhaps the striated construction of the corpus callosum.

A. The cephalic extremity of the transverse fibres of the splenium corporis callosi, as they lie over the cephalic extremity of the cornu inferius ventriculi lateralis. A large opening is shown through that portion of the splenium which covers in the caudalic portion of the ventriculus lateralis, and the beginning of the cornu.

B. Fasciculus subcallosus.

C. Hippocampus.

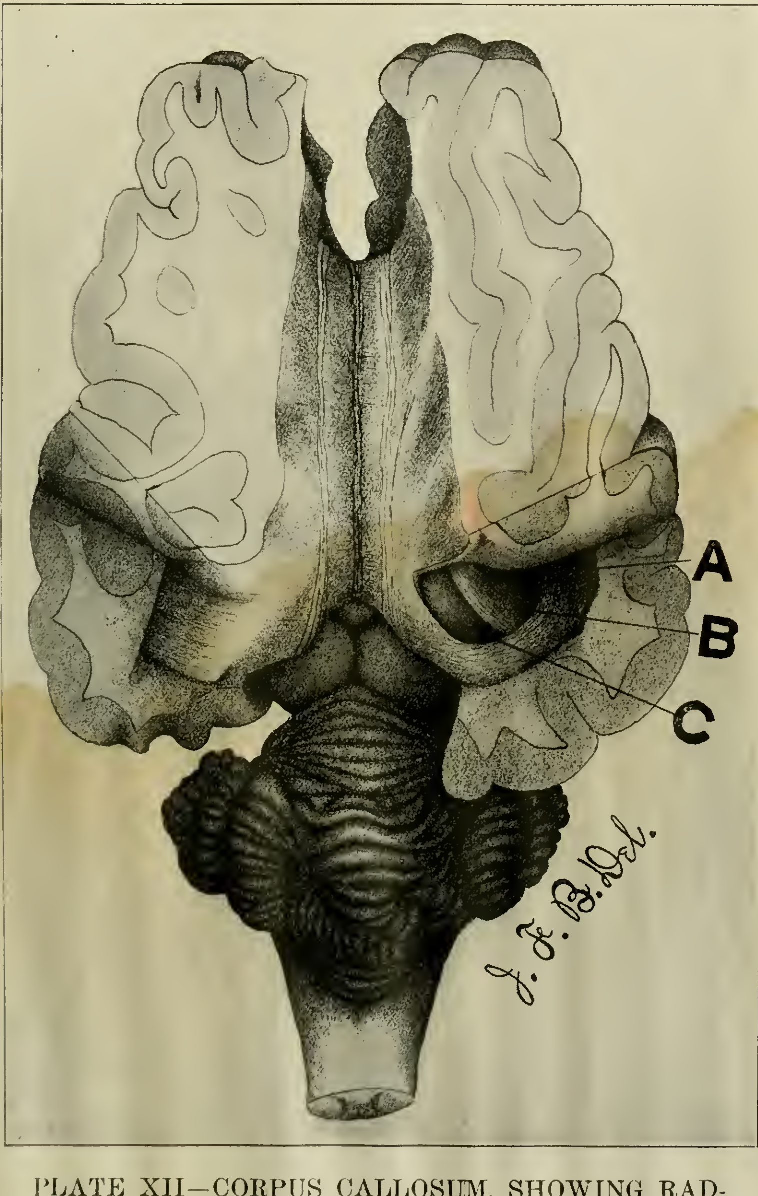

PLATE XII—CORPUS CALLOSUM, SHOWING RADIATING FIBRES OF THE SPLENIUM (x 1 2/3).

PLATE XIII.

DISSECTION FOR THE CAVITIES OF THE VENTRICULI LATERALES.

Illustrating the necessary dissections that are to be made to expose the cavities of the ventriculi laterales, and the structures forming their floors.

A. Cornu anterius ventriculi lateralis.

B. Nucleus caudatus.

C. Corpus callosum. Hanging from this portion of the corpus callosum will be seen the septum pellucidum, separating the two ventricular cavities; the septum pellucidum hangs from the ventral surface and is not shown in this drawing.

D. V. corporis striati.

E. Recessus triangularis.

F. Corpus fornicis.

G. Plexus chorioideus ventriculi lateralis.

H. Hippocampus.

I. Cingulum inferius (fasciculus subcallosus).

J. Cornu inferius ventriculi lateralis.

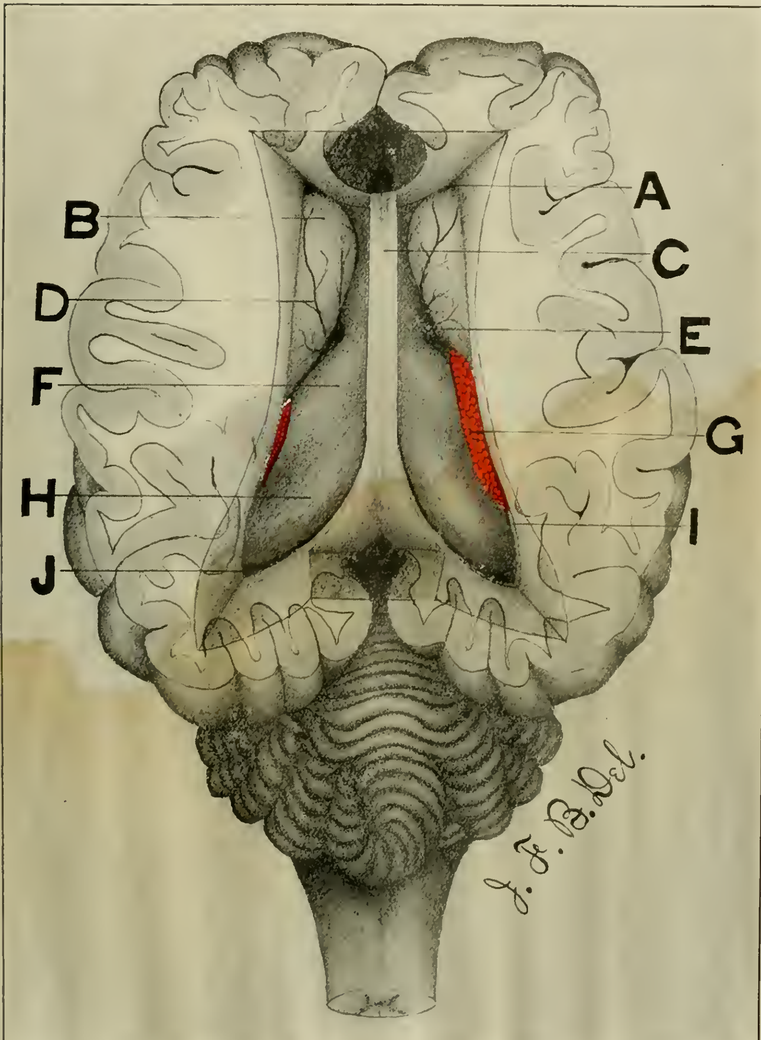

PLATE XIII—LATERAL VENTRICLES OF THE BRAIN (x 1 2/3).

PLATE XIV.

CONNECTIONS OF THE VENTRICULI LATERALES WITH VENTRICULUS TERTIUS.

This is designed for the purpose of showing the passages that apparently connect the ventriculi laterales with the ventriculus tertius and the structures that pass through them. The corpus callosum and the central portion of the corpus fornicis have been removed.

A. Septum pellucidum.

B. Columna fornicis.

C. V. terminalis.

D. Foramen interventriculare (foramen of Monroe) containing the V. terminalis and the plexus chorioideus ventriculi lateralis on its way from the ventriculus lateralis to become the plexus chorioideus ventriculi tertii. The margin of the corpus fornicis has been cut away on the left side to expose the fissure.

E. V. cerebri interna.

F. Plexus chorioideus ventriculi lateralis.

G. Margo corporis fornicis.

H. V. cerebri magna (Galen).

I. Plexus chorioideus ventriculi tertii.

J. Hippocampus.

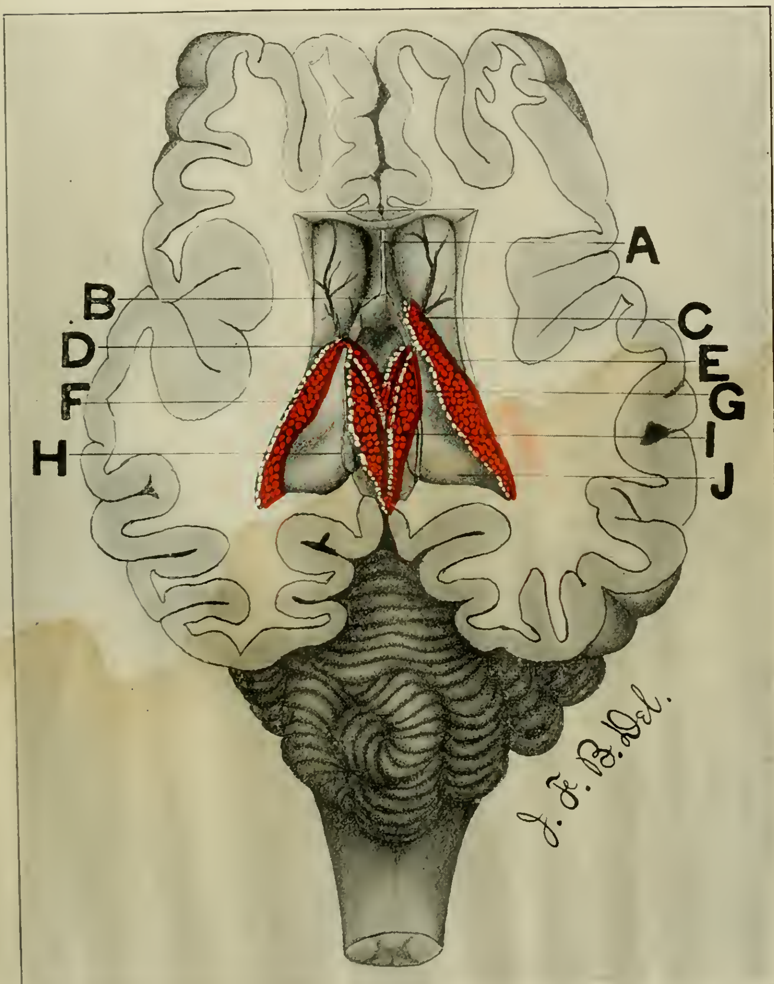

PLATE XIV—THIRD VENTRICLE AND CHOROID PLEXUS (x 1 2/3).

PLATE XV.

THE VENTRICULUS TERTIUS AND THE VENTRICULI LATERALES,

after the corpus fornicis and the tela chorioideus ventriculi lateralis with its plexus have been removed.

A. Columna fornicis.
B. Ventriculus tertius (corpus fornicis removed).
C. Thalamus.
D. Stria medullaris thalami.
E. Fimbria hippocampi.
F. Pulvinar.
G. Corpus pineale.
H. Colliculus superior.

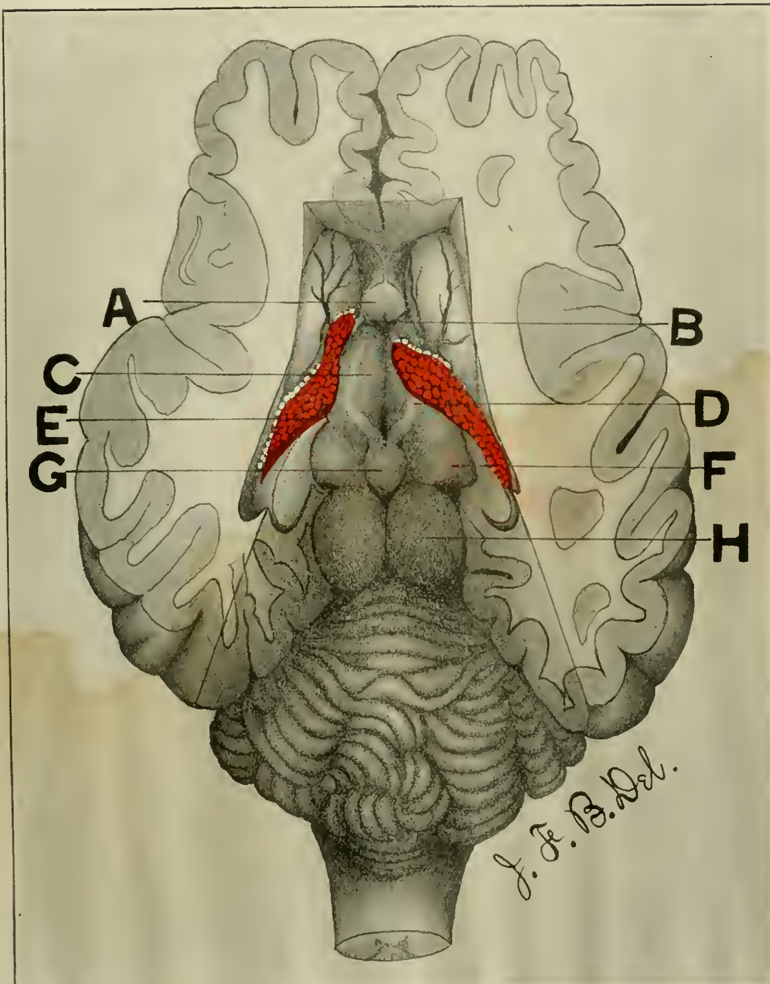

PLATE XV—LATERAL AND THIRD VENTRICLES OF THE BRAIN (x 1 2/3).

PLATE XVI.

ANOTHER STEP IN THE DISSECTION OF THE VENTRICULUS LATERALIS,

exposing the hippocampus, fimbria hippocampi and the plexus chorioideus attached to the pia seen passing into the cavity through the fissura transversa as they pass ventrad into the cornu inferior ventriculi lateralis.

A. Septum pellucidum.
B. Columna fornicis.
C. Recessus triangularis.
D. Plexus chorioideus ventriculi lateralis.
E. Corpus fornicis.
F. Hippocampus.
G. Fibres of the splenium.
H. Cingulum inferius (fasciculus subcallosus).
I. Fimbria hippocampi.
J. Plexus chorioideus.
L. Stria terminalis.

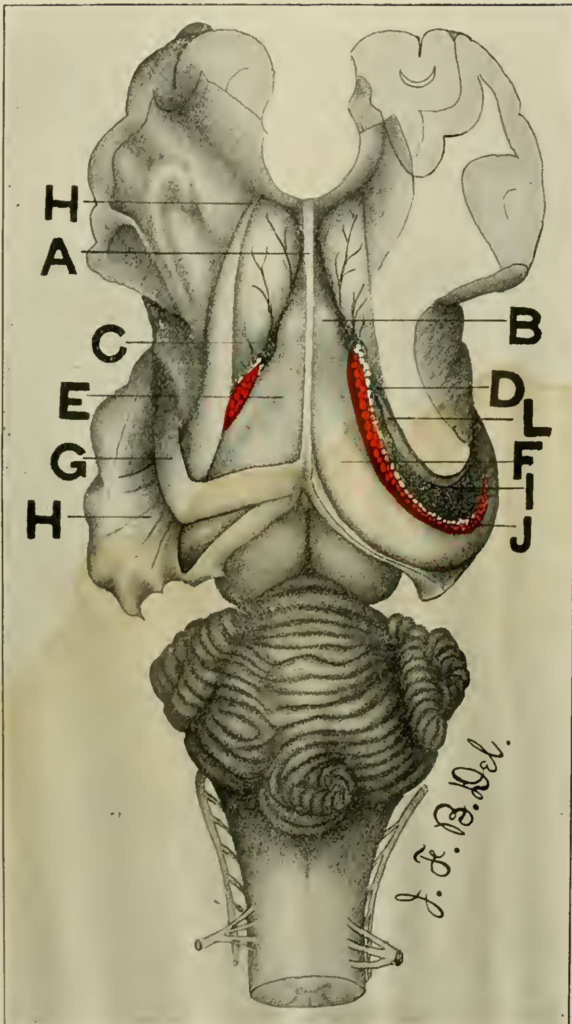

PLATE XVI—FORNIX, HIPPOCAMPUS AND CINGULUM INFERIOR (x 1 2/3).

PLATE XVII.

DISSECTION SHOWING THE MESIAL SURFACE OF THE LOBUS HIPPOCAMPI AND THE FASCIA DENTATA

as they wind around the crus cerebri.

A. Radix medialis bulbi olfactorii.
B. Commissura anterior.
C. Cephalic extremity of the lobus hippocampi.
D. Crus cerebri (transverse section).
E. Fascia dentata.
F. Fissura dentata.
G. Fasciola cinerea.
H. Stria medullaris thalami.
I. Thalamus.
J. Foramen interventriculare.
K. Ventriculus lateralis.
L. Nucleus caudatus.
M. Gyrus cinguli.

PLATE XVII—FASCIA DENTATA AND MESIAL SURFACE OF THE HIPPOCAMPUS (x 1 2/3).

PLATE XVIII.

SECTION OF THE CORPUS STRIATUM AND THALAMUS.

A composite drawing illustrating a horizontal section of the corpus striatum and the thalamus.

A. Nucleus caudatus.
B. Substantia alba insulae.
C. Nucleus lentiformis.
D. Capsula externa.
E. Claustrum.
F. Capsula interna.
G. Substantia grisea insulae.
H. Area medialis thalami.
I. Ventriculus tertius.
J. Area lateralis thalami.
K. Pars centralis thalami.
L. Trigonum habenulae.
M. Area posterior thalami.
N. Corpus pineale.
O. Fascia dentata.
P. Fissura dentata.
Q. Colliculus superior.
R. Cornu inferius ventriculi lateralis.
S. Genu capsulae internae.

PLATE XVIII THE CORPUS STRIATUM
(x 1 2/3).

PLATE XIX.

FIBRES OF THE COMMISSURA ANTERIOR.

This dissection shows particularly well the course taken by the greater number of fibres that constitute the commissura anterior. The drawing represents the central portion of the commissure located about 5 cm. dorsad to the chiasma opticum. The hypophysis is also shown.

A. Radix medialis bulbi olfactorii.
B. Commissura anterior, or commissura olfactoria.
H. Hypophysis.
J. Infundibulum.

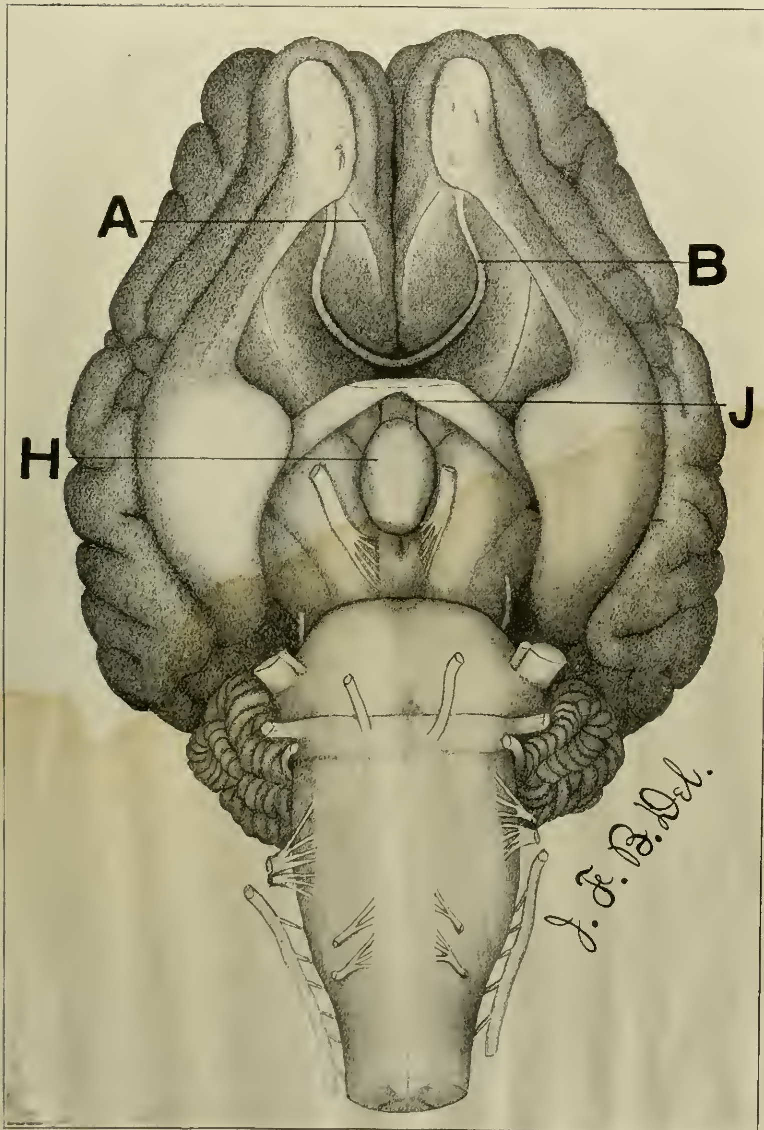

PLATE XIX—THE ANTERIOR COMMISSURE
(x 1 2/3).

PLATE XX.

THE DISSECTION OF THE COLUMNAE FORNICIS.

A. Pars libera columnæ fornicis.
B. Septum pellucidum (in part).
C. Substantia grisea.
D. Commissura anterior.
E. Pars tecta columnae fornicis.
F. Fasciculus thalamomamillaris.
G. Corpus mamillare.
H. Lamina pinealis.
J. Aquaeductus cerebri.
K. Commissura posterior.

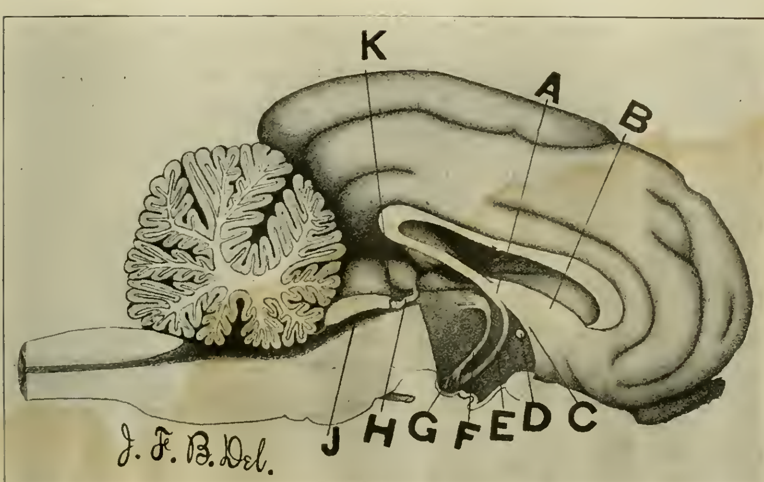

PLATE XX—PILLARS OF THE FORNIX.

PLATE XXI.

An oblique section of the caudalic portion of the cerebrum has been removed to expose the following structures in situ.

A. Colliculus superior.
B. Cornu inferius ventriculi lateralis.
C. Hippocampus.
D. Fascia dentata.
E. Pulvinar.
F. Tractus opticus.
G. Corpus geniculatum externum.
H. Tractus peduncularis transversus.
I. Brachium quadrigeminum inferius.
J. Colliculus inferior.
O. Corpus geniculatum externum.

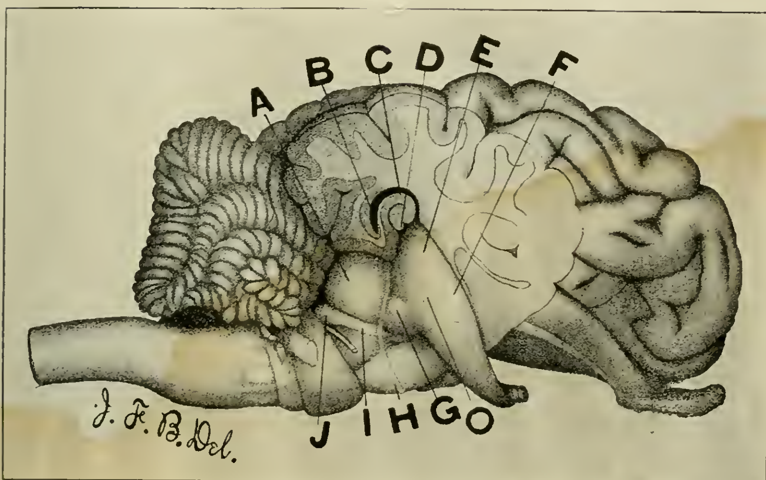

PLATE XXI—PROXIMAL TERMINATION OF OPTIC TRACT.

PLATE XXII.

THE CORONA RADIATA.

A. Hippocampus.

B. Fimbria hippocampi.

C. Portion of corona formed in part by the brachium quadrigeminum inferius.

D. Portion formed at the genu by the pyramis anterior.

E. Portion formed by the mesial fibres of the pyramis anterior.

F. Infundibulum and corpus mamillare.

G. Tracticus opticus.

I. Brachium quadrigeminum inferius.

J. Lateral fibres of the crus cerebri, (trigonum lemnisci).

K. Brachium conjunctivum.

L. Pyramis anterior, some fibres of.

PLATE XXII—THE CORONA RADIATA.

PLATE XXIII.

VENTRAL SURFACE OF THE PONS, TRAPEZIUM, AND MEDULLA OBLONGATA.

A. Pons.
B. Sulcus basilaris.
C. Flocculus.
D. Trapezium.
E. Oliva.
F. Pyramis ventralis.
G. Ramus ascendens N. trigemini, (tractus spinalis N. trigemini).
H. Fasciculus lateralis minor.
I. Sulcus ventralis lateralis.
J. Funiculus lateralis.
K. N. accessorius (spinal portion).
L. Sulcus ventralis.
N. Ligamentum denticulatum.
O. Pia.
5. N. trigeminus (the larger is the sensory and the smaller the motor portion).
6. N. abducens.
7. N. facialis.
8. N. acusticus.
9. N. glossopharyngeus.
10. N. vagus.
11. N. accessorius.
12. N. hypoglossus.

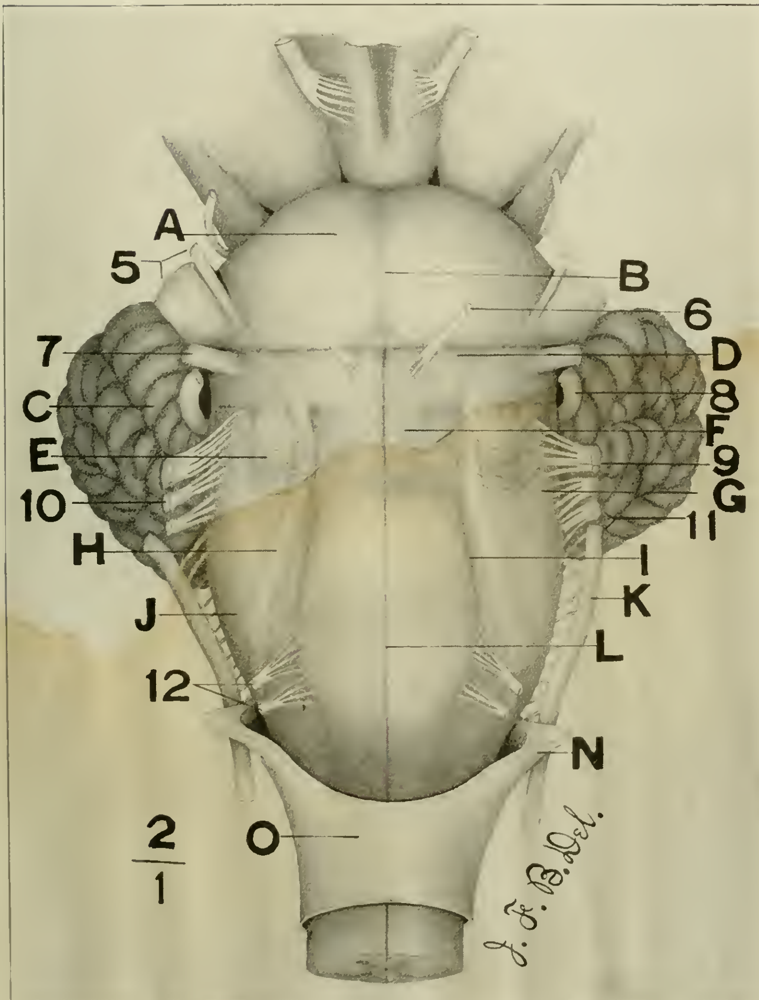

PLATE XXIII — VENTRAL SURFACE OF PONS, TRAPEZIUM AND MEDULLA OBLONGATA (x 2 2/3).

PLATE XXIV.

LATERAL SURFACE OF THE CRUS CEREBRI, PONS, TRAPEZIUM, AND THE MEDULLA OBLONGATA.

A. Corpus geniculatum internum.
B. Tractus opticus.
C. Fascies medialis cruris cerebri.
D. N. oculomotorius.
E. Tractus peduncularis transversus.
F. Tractus pyramis pedunculi cerebri.
G. Brachium quadrigeminum inferius or tractus cerebro-thalmicus.
H. N. patheticus.
I. Pons.
J. N. trigeminus.
K. N. abducens.
L. Trapezium.
M. N. facialis.
N. Tractus lateralis minor.
O. Oliva.
P. Pyramis.
Q. Funiculus lateralis.
R. Sulcus lateralis ventralis.
S. Sulcus lateralis dorsalis.
T. Fasciculus cuneatus.
U. Clava.
V. Corpus restiforme.
W. N. acusticus.
X. Portio motor N. trigemini.
Y. Brachium pontis.
Z. Brachium conjunctivum.
1. Colliculus inferior.
2. Colliculus superior.
3. Corpus pineale.
4. Pulvinar.
5. Tractus spinalis N. trigemini.
6. Trigonum lemnisci.

PLATE XXIV—LATERAL SURFACE OF CRUS CEREBRI, PONS, TRAPEZIUM, AND MEDULLA OBLONGATA (x 2 2/3).

PLATE XXV.

DORSAL SURFACE OF THE MEDULLA AND PONS, WITH FLOOR OF THE VENTRICULUS QUARTUS.

A. Ventriculus tertius.
B. Stria medullaris thalami.
C. Pulvinar.
D. Corpus pineale.
E. Corpus geniculatum internum.
F. Sulcus intercollicularis,
G. Colliculus superior.
H. N. patheticus.
I-X. Sulcus limitans fossae rhomboideae.
J. Colliculus inferior.
K. N. trigeminus.
L. Colliculus facialis.
M. Fovea anterior.
N. Brachium conjunctivum.
O. Sulcus longitudinalis fossae rhomboideae.
P. Brachium pontis.
Q. Tuberculum acusticum.
R. Fossa rhomboidea.
S. Sulcus semilunaris.
T. Corpus restiforme.
U. Area acustica.
V. Fovea posterior.
W. Eminentia medialis.
Y. Clava.
Z. Canalis centralis medullae spinalis.
1. Obex.
2. Depressio interfusiformis.
3. Sulcus fusiformis.
4. Fasciculus fusiformis.
5. Sulcus intermedius dorsalis.
6. Fasciculus gracilis.
7. Sulcus dorsalis.
8. Fasciculus cuneatus.
9. Sulcus lateralis dorsalis.
10. Fasciculus cerebellospinalis.

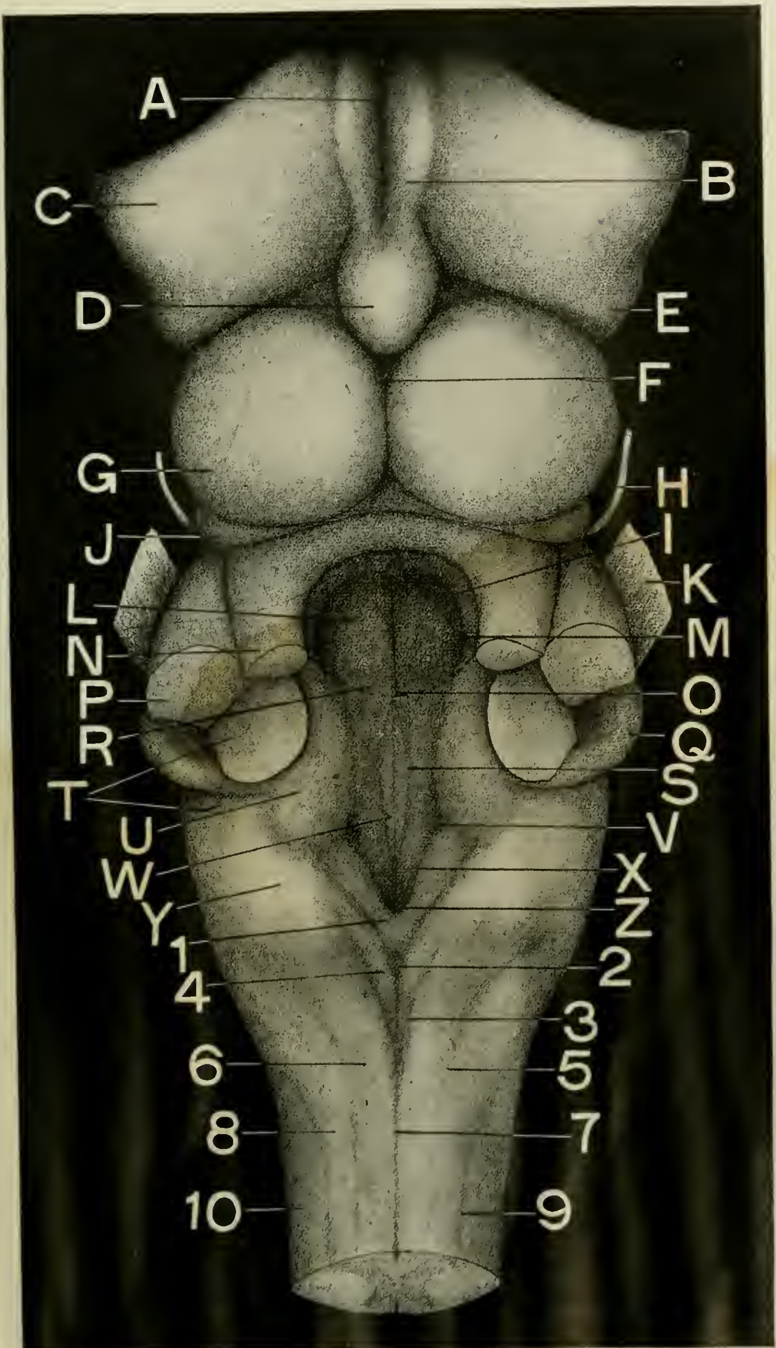

PLATE XXV—DORSAL SURFACE OF PONS AND THE MEDULLA OBLONGATA (x 2 2/3).

PLATE XXVI.

Fig. 1. A CORONAL SECTION THROUGH THE BULBI OLFACTORII,

beginning on the dorsal surface of the encephalon near the narrowest portion of the gyrus medialis anterior.

A. Fissura longitudinalis.
B. Fissura coronalis.
C. Gyrus frontalis inferior.
D. Gyrus orbitalis.
F. Ventriculus bulbi olfactorii.
P. Bulbus olfactorius.

Fig. 2. A SECTION THROUGH THE CEPHALIC PORTIONS OF THE VENTRICULI LATERALES AND SEPTUM PELLUCIDUM,

beginning in the fissura coronalis.

A. Fissura longitudinalis.
G. Corpus callosum.
I. Septum pellucidum.
J. Nucleus caudatus.
K. Capsula interna.
L. Tractus olfactorius.
M. Rostrum corporis callosi.
N. Capsula externa.
O. Ventriculus lateralis.

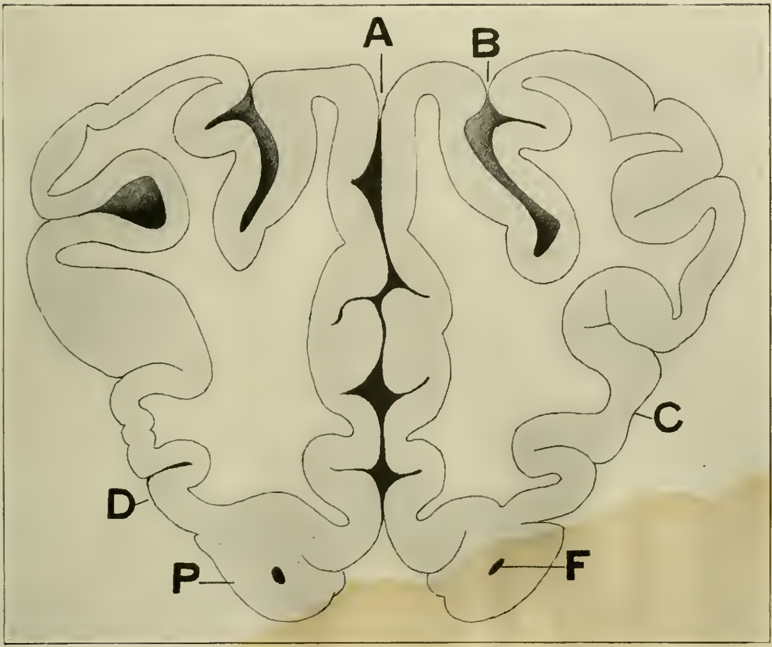

Fig. 1—Coronal Section Through the Olfactory Bulbs (x 2).

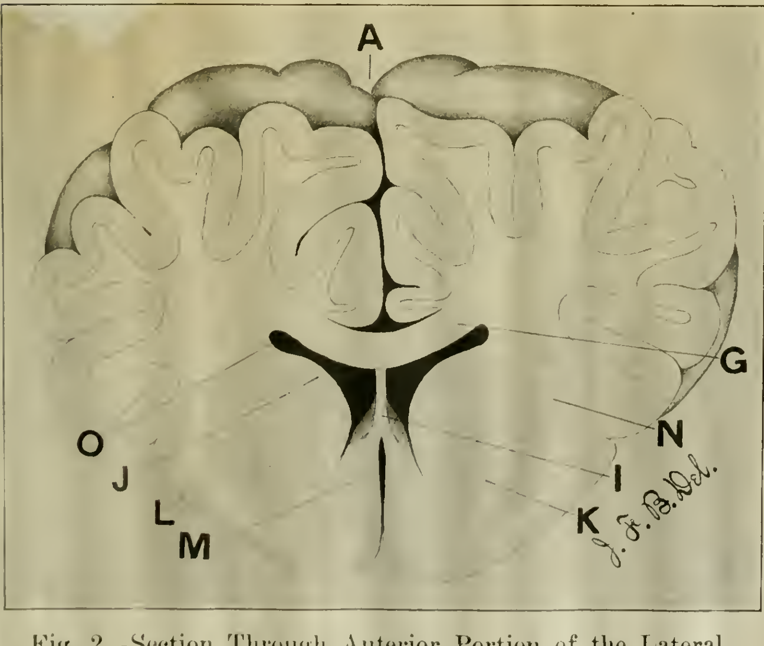

Fig. 2—Section Through Anterior Portion of the Lateral Ventricles (x 2).

PLATE XXVI.

PLATE XXVII.

Fig. 1. CARRY THE SECTION THROUGH THE ENCEPHALON,

parallel to and just cephalad to the fissura cerebri lateralis.

A. Fissura longitudinalis.
E. Fissura suprasylvia.
F. Nucleus lentiformis.
G. Corpus callosum.
H. Insula.
I. Septum pellucidum.
K. Capsula interna.
N. Capsula externa.
O. Ventriculus lateralis.
Q. Substantia alba insulae.
R.′ Ramus anterior fissurae lateralis cerebri.
S. Claustrum.
T. Commissura anterior.
3. Nucleus caudatus.
W. Stria terminalis.
U. Columna fornicis.

Fig. 2. BEGIN THE INCISION ON THE DORSAL SURFACE OF THE ENCEPHALON

about midway between the fissura cruciata and polus posticus, completing the section cephalad to the opening in the infundibulum.

A. Fissura longitudinalis.
E. Fissura suprasylvia.
G. Corpus callosum.
J. Ventriculus tertius.
K. Capsula interna.
L. Recessus opticus ventriculi tertii.
O. Ventriculus lateralis.
P. Thalamus.
R″. Ramus posterior fissuræ lateralis cerebri.
U. Corpus fornicis.
X. Fasciculus subcallosus.
Y. Plexus chorioideus ventriculi tertii.
Z. Substantia intermedia.
1. Tractus opticus.
2. Infundibulum.
4. Lobus hippocampi.
5. Fissura dentata.

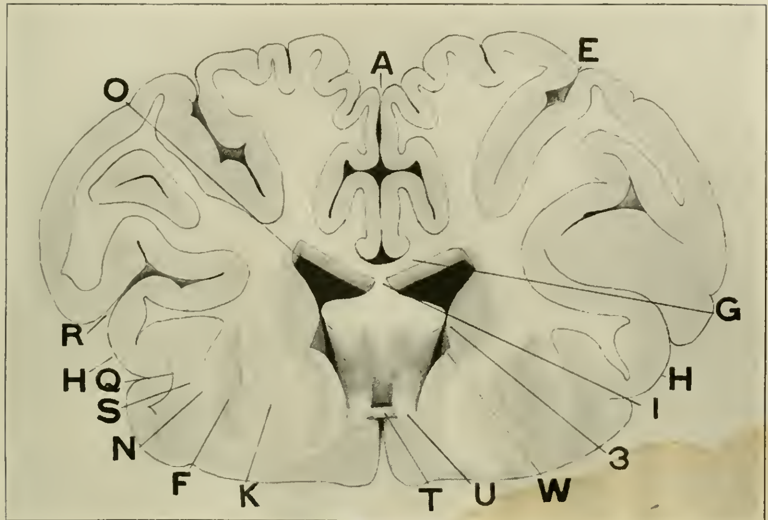

Fig. 1—Section Just Posterior to the Fissure of Sylvius (x 2).

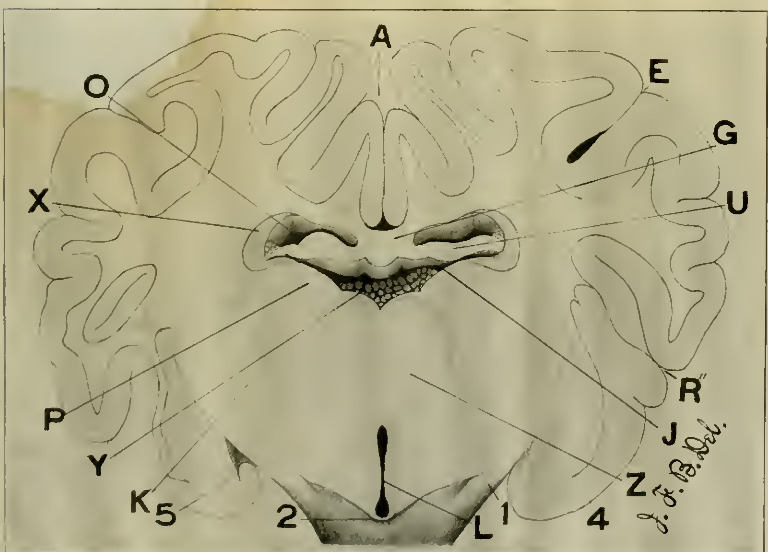

Fig. 2—Section Through Substantia Intermedia (x 2).
PLATE XXVII.

PLATE XXVIII.

Fig. 1. BEGIN THE INCISION 6 MM. CAUDAD TO THE LAST SECTION,

reaching the ventral surface just caudad to the infundibulum.

A. Fissura longitudinalis.
C. Fasciola cinerea.
E. Fissura suprasylvia.
F. Fissura dentata.
G. Corpus callosum.
J. Ventriculus tertius.
O. Ventriculus lateralis.
P. Fimbria hippocampi.
1. Tractus opticus.
2. Infundibulum.
3. Hippocampus.
4. Substantia grisea fissurae dentatae.
5. Cornu inferius ventriculi lateralis.
6. Lobus hippocampi.
7. Pulvinar.
8. Lamina pinealis.
9. Columna fornicis.
10. Corpus mamillare.
15. Corpus pineale.

Fig. 2. MAKE THE INCISION ABOUT 2.5 CM. CEPHALAD TO THE POLUS POSTICUS,

ending on the ventral surface about the tractus peduncularis transversis.

A. Fissura longitudinalis.
E. Fissura suprasylvia.
3. Hippocampus.
5. Cornu inferius ventriculi lateralis.
6. Lobus hippocampi.
11. Aquæductus cerebri.
12. Corpus geniculatum internum.
13. Colliculus superior.
14. Tractus pyramidalis.

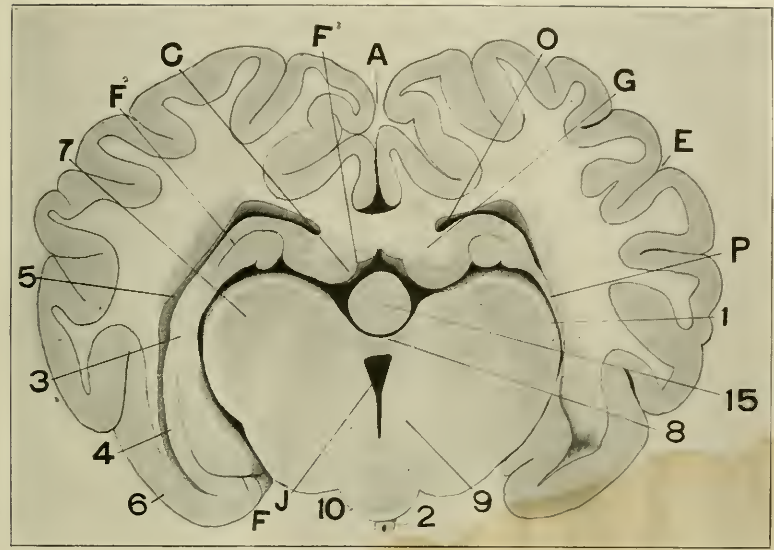

Fig. 1 Section Through the Corpus Pineale.

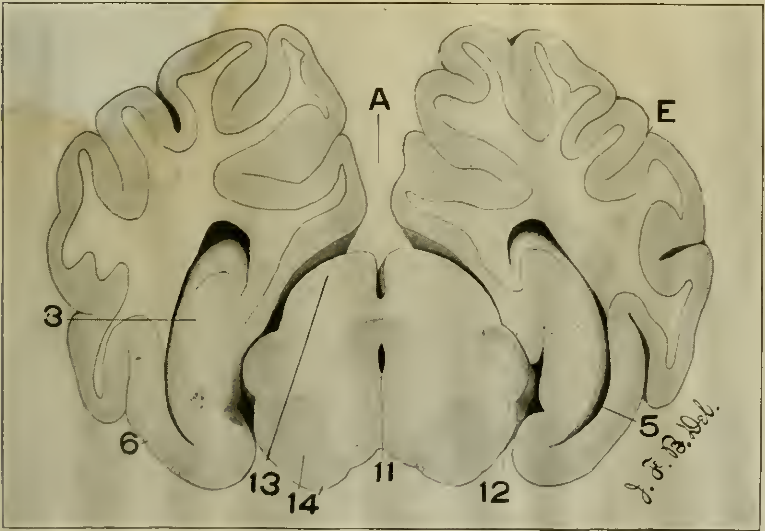

Fig. 2—Section 2.5 mm. Anterior to the Posterior Extremity of the Cerebrum (x 2).

PLATE XXVIII.

PLATE XXIX.

Fig. 1. SECTION THROUGH THE CRURA AND COLLICULI SUPERIORES.

Fig. 2. SECTION THROUGH THE CRURA intermediate between the N. oculomotorius and the cephalic border of the pons.

Fig. 3. SECTION IMMEDIATELY CEPHALAD TO THE PONS.

A. Nn. oculomotorii.
B. Tractus pyramidalis pedunculi.
C. Striae longitudinales (sections of).
D. Aquaeductus cerebri.
E. Fibrae transversae colliculi superiores.
F. Tractus cerebro-thalamus.
G. Sulcus inter-colliculus.
H. Colliculus superior.
I. Tractus peduncularis transversus.
J. Corpus geniculatum internum.
K. Tractus colliculus inferius.
L. (a) Stratum opticum in fig. 2.
(b) Brachium conjunctivum in fig. 3.
N. Crus.
O. Ventriculus quartus.
P. Colliculus inferior.
Q. Nucleus ruber.

PLATE XXIX—SECTIONS THROUGH THE COLLICULUS SUPERIOR AND CRURA CEREBRI (x 2 2/3).

PLATE XXX.

Fig. 1. 2mm. CEPHALAD TO THE CAUDAL BORDER OF THE PONS.

Fig. 2. THROUGH THE N. TRIGEMINUS.

Fig. 3. THROUGH THE CENTER OF THE TRAPEZIUM.

A. Brachium pontis.

B. Pyramis anterior. Fasciculus longitudinalis superficialis pontis.

C. Stria longitudinalis medialis.

L. Brachium conjunctivum.

O. Sulcus longitudinalis fossae rhomboideae ventriculi quarti.

Q. Fibrae pontis superficiales ventrales.

R. Raphe pontis.

T. Corpus restiforme.

U. Velum medullare anterius.

V. Eminentia medialis.

W. Fibrae pontis superficiales laterales.

X. Eminentia facialis.

Y. Vermis cerebelli minor.

Z. Nucleus olivaris inferior.

5. N. trigeminus.

6. N. abducens.

7. N. facialis.

PLATE XXX—SECTIONS THROUGH THE PONS AND TRAPEZIUM (x 2 2/3).

PLATE XXXI.

Fig. 1. THROUGH THE OLIVAE.

Fig. 2. THROUGH THE N. ACUSTICUS.

Fig. 3. THROUGH THE CAUDAL THIRD OF THE THE VENTRICULUS QUARTUS.

B. Pyramis.
C. Stria longitudinalis profundis.
F. Sulcus limitans fossae rhomboideae.
I. Eminentia medialis.
O. Sulcus longitudinalis fossae rhomboideae.
P. Area acustica.
Q. Ventriculus quartus.
R. Raphe.
T. Corpus restiforme.
Z. Oliva (nucleus of).
5. Radix ascendens N. trigemini.
8. N. acusticus.

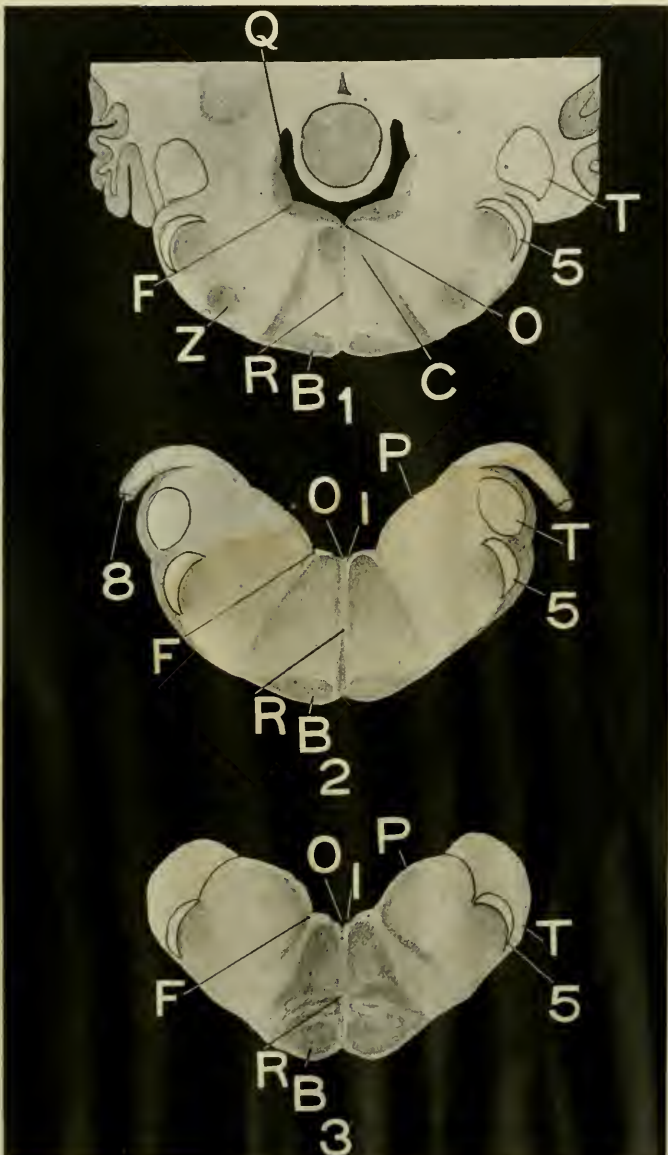

PLATE XXXI—SECTIONS THROUGH THE MEDULLA OBLONGATA (x 2 2/3).

PLATE XXXII.

Fig. 1. SECTION THROUGH THE CAUDAL FOURTH OF THE VENTRICULUS QUARTUS.

Fig. 2. SECTION AT THE ENTRANCE OF THE CANALIS CENTRALIS.

Fig. 3. SECTION THROUGH THE CAUDAL BORDER OF THE OBEX.

Fig. 4. SECTION OF MEDULLA SPINALIS.

B. Pyramis.
D. Columna dorsalis.
G. Substantia gelatinosa.
H. Columna ventralis.
J. Canalis centralis.
K. Substantia gelatinosa centralis.
L. Fissura ventralis.
R. Raphe.
T. Corpus restiforme.
X. Obex.
5. Radix ascendens N. trigemini.
7. Sulcus dorsalis.
12. Eminentia hypoglossi.

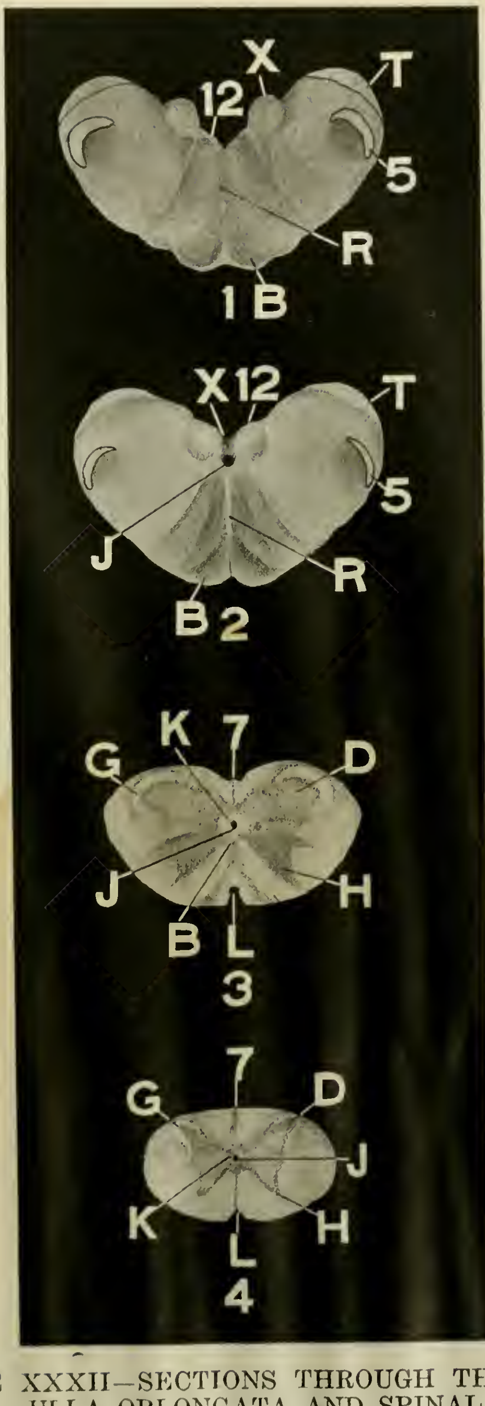

PLATE XXXII—SECTIONS THROUGH THE MEDULLA OBLONGATA AND SPINAL CORD (x 2 2/3).

PLATE XXXIII.

ENLARGED SECTION OF THE MEDULLA SPINALIS.

A. Fissura ventralis.
B. Funiculus ventralis.
C. Sulcus ventralis lateralis.
D. Columna lateralis.
E. Funiculus lateralis.
F. Fasciculus lateralis minor.
G. Processus reticularis.
H. Fasciculi longitudinales dorsales.
I. Fasciculus cerebellospinalis.
J. Sulcus lateralis dorsalis.
K. Substantia gelatinosa.
L. Fasciculus cuneatus.
M. Sulcus intermedius dorsalis.
N. Fasciculus gracilis.
O. Sulcus dorsalis.
P. Fasciculus fusiformis.
Q. Commissura dorsalis.
R. Columna dorsalis.
S. Radix dorsalis nervi spinalis.
T. Canalis centralis.
U. Commissura ventralis grisea.
V. Fasciculus intercommissuralis (Dexel & Margulies) ventralis.
W. Radix spinalis N. accessorii.
X. Commissura ventralis alba.
Y. Columna ventralis.
Z. Radix ventralis nervi spinalis.

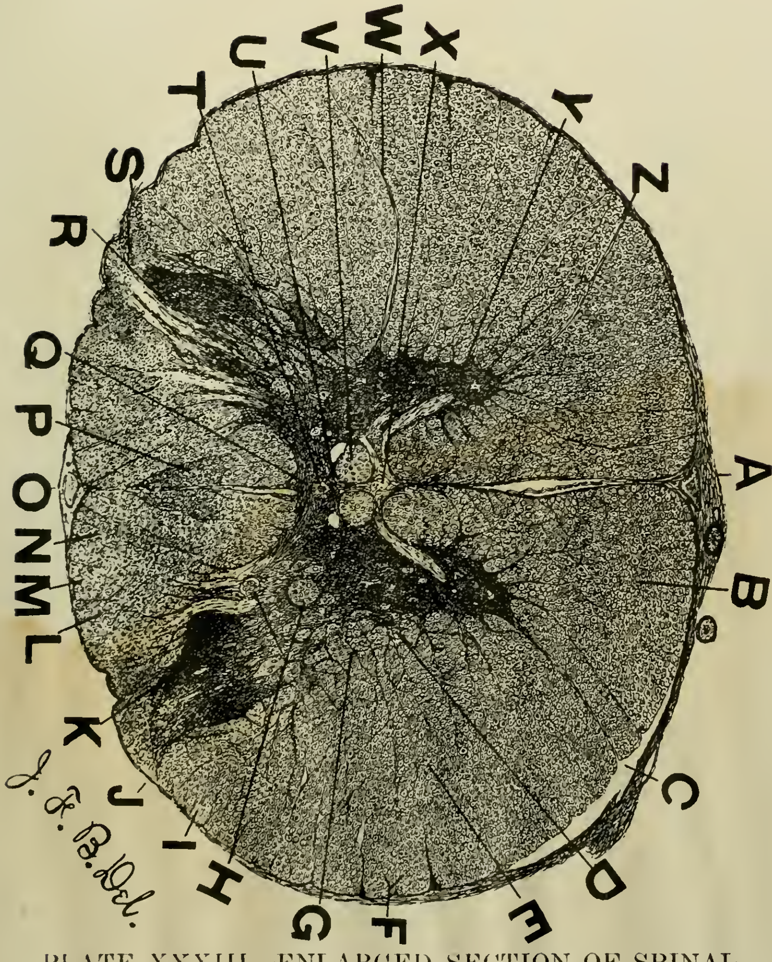

PLATE XXXIII—ENLARGED SECTION OF SPINAL CORD .5 CM., CAUDAD TO MEDULLA OBLONGATA.

PLATE XXXIV.

SECTION THROUGH THE LOWER PORTION OF THE MEDULLA OBLONGATA, SHOWING THE DECUSSATION OF THE PYRAMIDAL FIBRES.

A. Fissura ventralis,
B. Pyramis,
C. Pyramis, decussation of,
D. Fasciculi longitudinales dorsales,
E. Fasciculus cuneatus,
F. Fasciculus Gracilis,
G. Fasciculus fusiformis,
H. Radix dorsalis N. spinales,
I. Substantia gelatinosa (Rolando),
J. Fasciculus cerebellospinalis,
K. Formatio reticularis,
L. N. hypoglossus (caudal extremity),
O. Fasciculus lateralis minor,

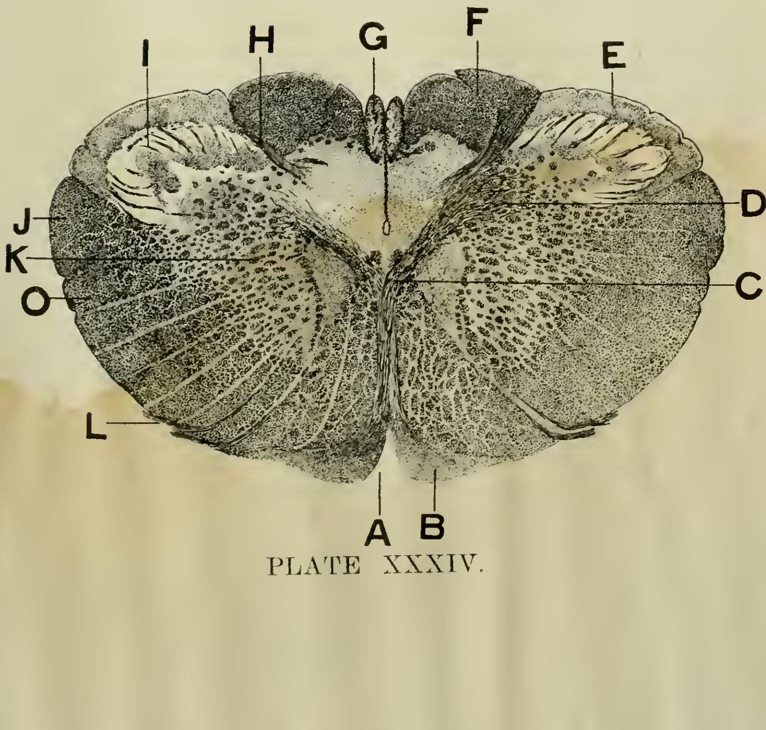

PLATE XXXIV.

PLATE XXXV.

SECTION THROUGH THE NUCLEI ARCUATI.

A. Sulcus ventralis.
B. Pyramis.
C. Nuclei arcuati.
D. N. hypoglossus.
E. Fasciculus lateralis minor.
F. Fibrae arcuatae externae.
G. N. Glossopharyngi.
H. Corpus restiforme.
I. Nucleus cuneatus.
J. Nucleus gracilis.
K. Fasciculus fusiformis.
L. Nucleus hypoglossus.
M. Taenia ventriculi quarti.
N. Ventriculus quartus.
O. Ramus obiscis.
P. Nucleus glossopharyngeus.
Q. Fasciculus solitarius.
R. N. vagus.
S. Tractus spinalis N. trigemini.
T. Nucleus tractus spinalis N. trigemini.
U. Formatio reticularis grisea.
V. Formatio reticularis alba.

PLATE XXXV.—SECTION THROUGH THE NUCLEI ARCUATI.

PLATE XXXVI.

SECTION THROUGH THE CAUDAL THIRD OF THE FOURTH VENTRICLE.

A. Pyramis ventralis.
B. Lemniscus medialis.
C. Fasciculus lateralis minor (Gower).
D. Tractus spinalis N. tragemini.
E. Corpus restiforme.
F. Nucleus vagi, dorsal and ventral areas.
G. Plexus chorioideus ventriculi quarti.
H. Taenia ventriculi quarti.
I. Tractus solitarius N. vagi.
J. Nervus vagus.
K. Fibræ arcuatæ externæ.
L. Eminentia medialis.
M. Nucleus ambiguus N. vagi.
N. Fibræ arcuatæ internæ.

PLATE XXXVI—SECTION THROUGH THE CAUDAL THIRD OF THE FOURTH VENTRICLE.

PLATE XXXVII.

SECTION THROUGH THE TRAPEZIUM, COCHLEAR AND VESTIBULAR NUCLEI.

A. N. cochlæ.
B. Nucleus dorsalis N. cochlearis.
C. Striæ medullares.
D. Nucleus ventralis N. cochlearis.
E. Corpus restiforme.
F. Fibres from the nucleus ventralis N. cochlearis.
G. Fibres from the nucleus dorsalis N. cochlearis.
H. Nervous vestibuli.
I. Nucleus lateralus N. vestibuli (Deiter).
J. Radix descendens N. vestibuli.
K. Nucleus olivæ.
L. Nucleus N. facialis.
M. Pars prima N. facialis.
N. Nucleus N. abducentis.
O. Genu N. facialis.
P. Fibres of the trapezium.
Q. Nucleus tractus spinalis N. trigemini.
R. Tractus spinalis N. trigemini.
S. Tractus pyramidalis.
T. N. abducens.
U. Fibræ arcuatæ externæ.
V. Decussation of the striæ medullares from the dorsal and ventral cochlear nuclei.
W. Formatio reticularis.
X. Fasciculus lateralis minor.
Y. Nucleus dorsalis N. vestibuli.
Z. Area acustica.

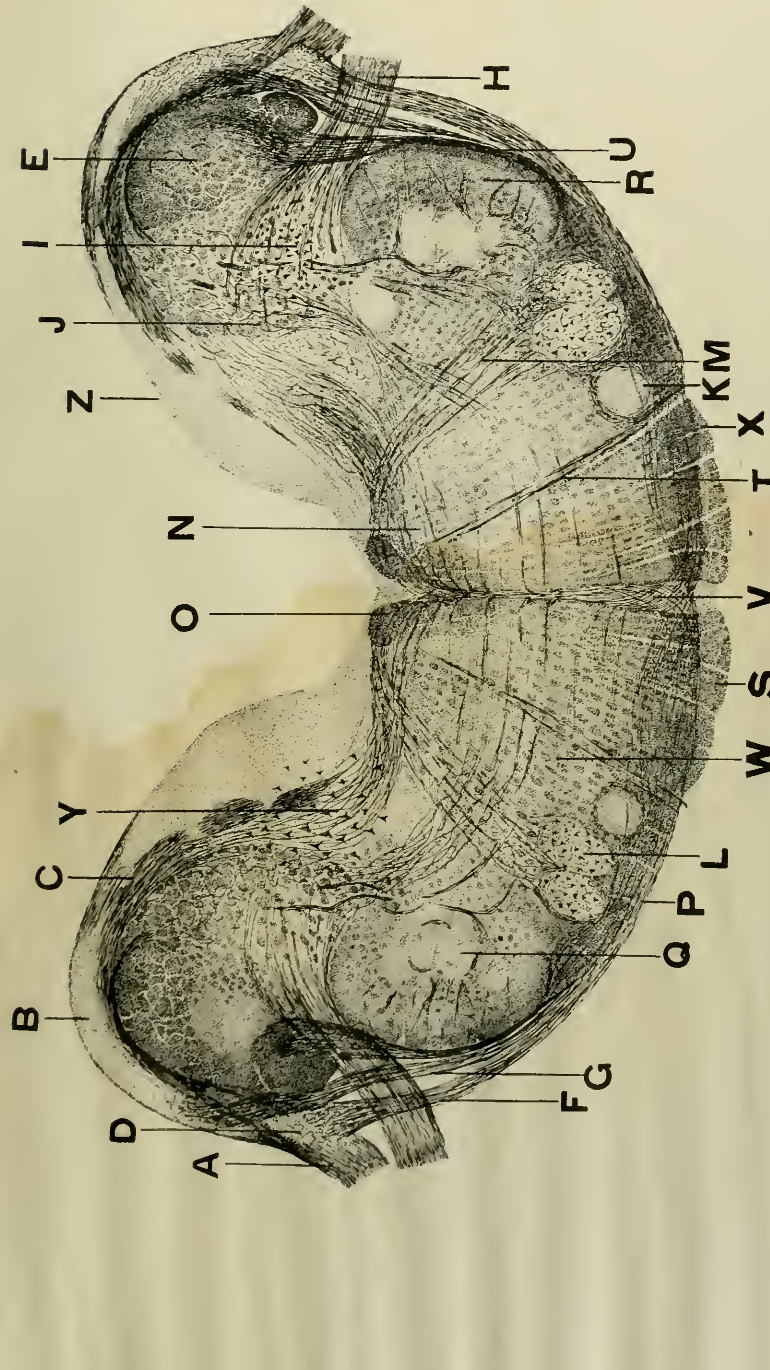

PLATE XXXVII—SECTION THROUGH THE TRAPEZIUM
COCHLEAR AND VESTIBULAR NUCLEI.

PLATE XXXVIII.

SECTION THROUGH THE COLLICULI SUPERIORES.

A. N. oculomotorius, fibres leading from its nucleus.
B. Pyramis.
C. Corpus geniculatus externum.
D. Stratum opticum.
E. Colliculus superior.
F. Stratum griseum centrale.
G. Corpus geniculatum internum.
H. Aquaeductus cerebri.
I. Nucleus ruber.
J. Fasciculus retroflexus (Meynert).
L. Lamina quadrigemina.

PLATE XXXVIII—SECTION THROUGH THE COLLICULI SUPERIORES.

PLATE XXXIX.

THE BASE OF THE SKULL

with the dura mater and the nervi cerebrales in position.

1. N. olfactorius.
2. Tractus opticus.
3. N. oculomotorius.
4. N. patheticus.
5. N. trigeminus.
6. N. abducens.
7. N. facialis.
8. N. acusticus.
9. N. Glosso-pharyngeus.
10. N. vagus.
11. N. accessorius.
12. N. hypoglossus.
AA. Sinus frontales.
B. Crista galli.
C. Fossa olfactoria.
D. Fossa frontalis.
E. Foramen opticum.
F. Commissura optica.
G. Recessus infundibuli.
H. Infundibulum.
I. Foramen diaphragmatis sellae.
J. Arteria carotis interna.
K. Fossa hippocampi.
L. Tentorium cerebelli.
M. Foramen magnum.
N. Meatus acusticus internus.
P. Foramen jugulare.
R. Dura mater.
S. Fossa parietalis.
T. Condylus occipitalis.

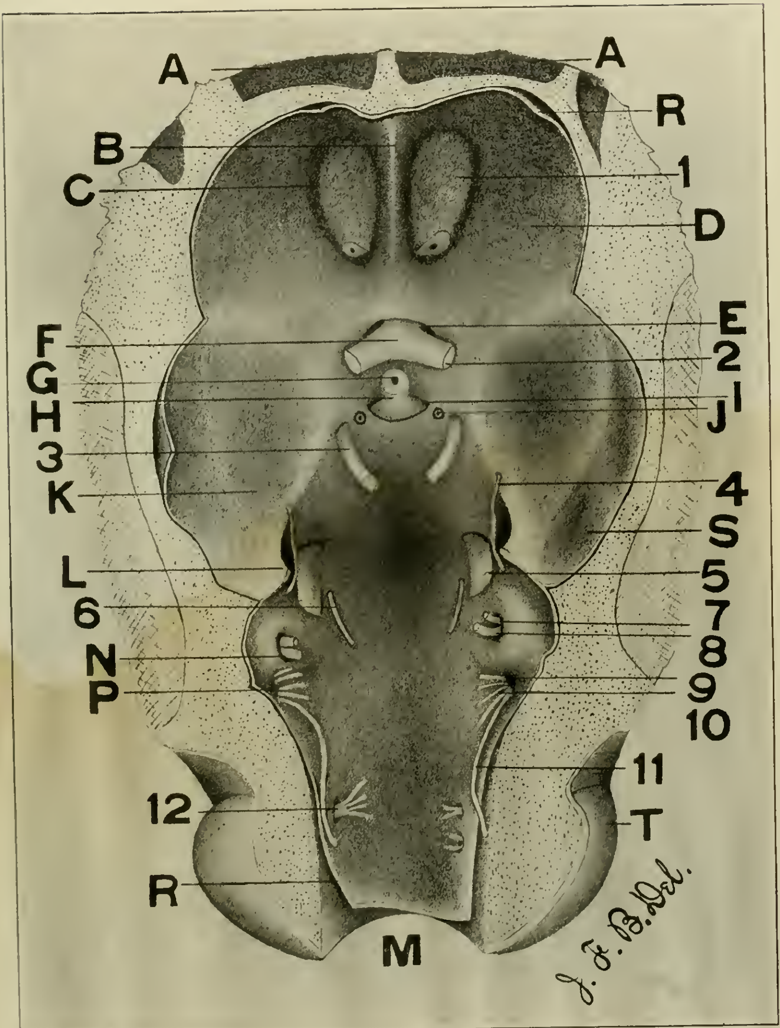

PLATE XXXIX—BASE OF SKULL SHOWING DURA MATER WITH EXITS OF CRANIAL NERVES (x 1 1/3).

PLATE XL.

BASIS CRANII.

A. Sinus frontales.
B. Lamina cribrosa.
C. Crista galli.
D. Sulcus chiasmatis.
E. Fissura sphenoidalis.
F. Processus clinoideus anterior.
G. Fossa hypophyseos (sella turcica).
H. Sulcus caroticus.
I. Foramen ovale.
J. Processus clinoideus posterior.
K. Fossa jugularis.
L. Dorsum sellae.
M. Sulcus sigmoideus.
N. Meatus acusticus internus.
O. Condylus occipitalis.
P. Foramen condyloideum.
R. Foramen occipitale magnum.
S. Pars petrosa.
T. Os basilare.

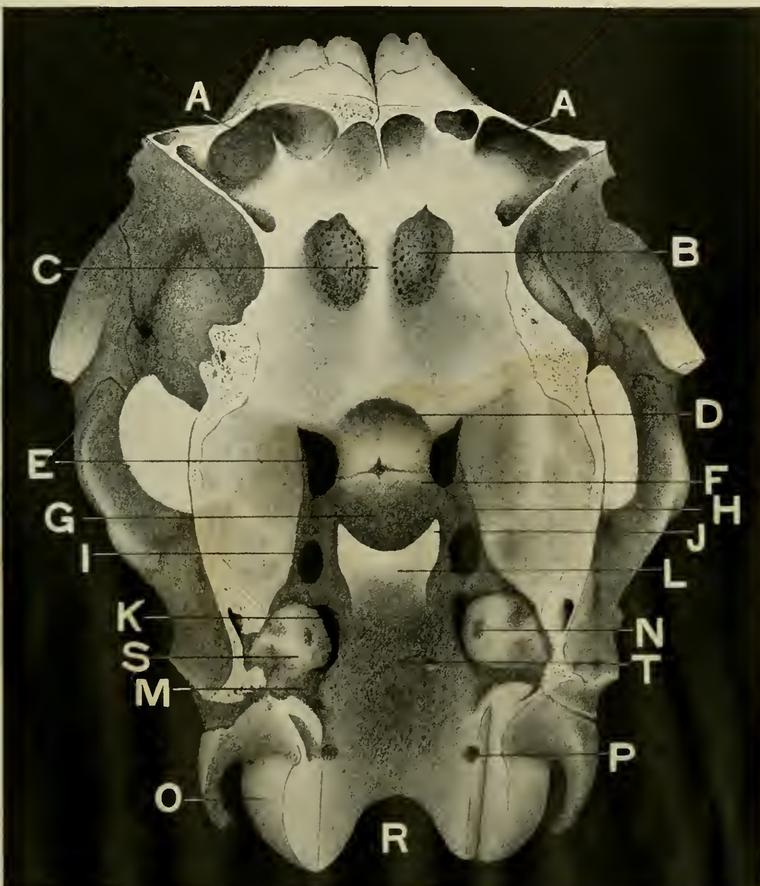

PLATE XL.—BASE OF THE SKULL (x 1 1/3).

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